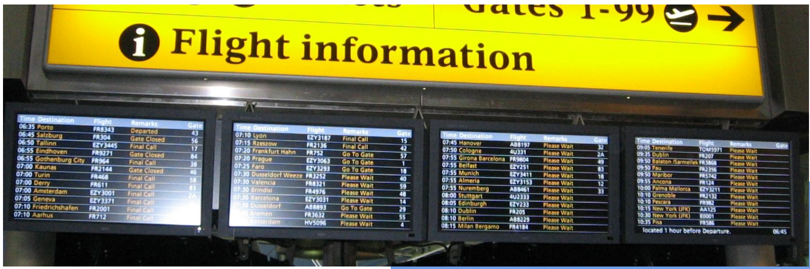
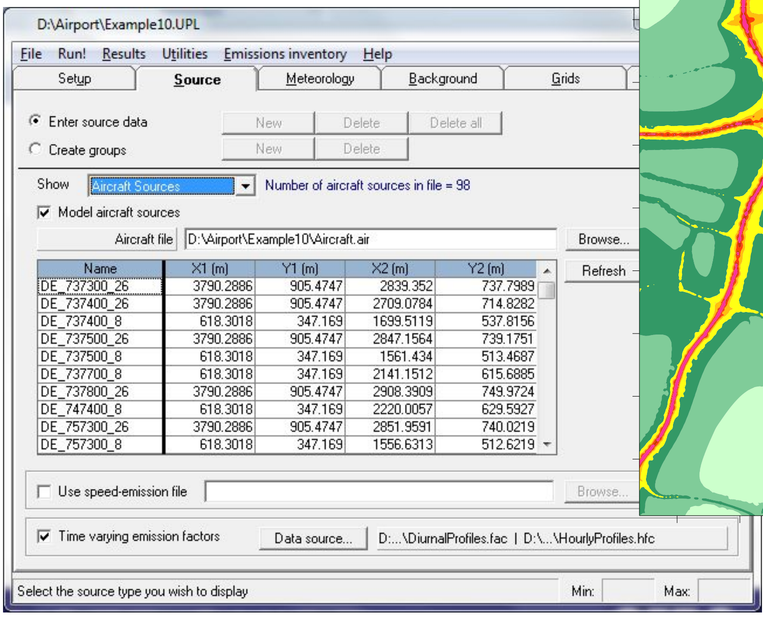
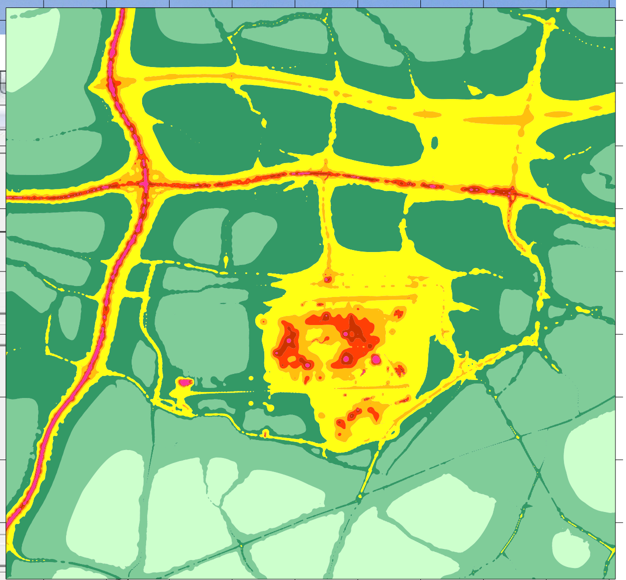
ADMS-Airport

Airport Air Quality Management System
Version 3.4







USER GUIDE

CERC

ADMS-Airport

Airport Air Quality Management System

User Guide

(Supplement to the ADMS-Urban User Guide)

Version 3.4

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SECTION 1 Introduction

1.1 Introduction

ADMS-Airport is a PC-based air quality management system for airports. It includes emissions calculation tools, GIS tools and a model of dispersion in the atmosphere of pollutants released from aircraft, road traffic, industrial and domestic sources for airports in rural or complex urban environments. ADMS-Airport models these pollutants using aircraft jet, point, line, area, volume, and grid source types. Aircraft engine (jet) sources are modelled as jets from an accelerating source.

ADMS-Airport has been used to model air quality at London's Heathrow airport for base case and future year scenarios as part of the Department for Transport's (DfT) Project for the Sustainable Development of Heathrow (PSDH) – Adding Capacity at Heathrow (**DfT 2007**). This followed the PSDH Model Inter-comparison Study (**DfT 2006**) and the recommendations of the PSDH independent review panel that

> *'ADMS-Airport should be used for future air quality modelling studies at Heathrow, associated with PSDH'.*

ADMS-Airport is also one of the participating models in the ICAO CAEP model exercises (International Civil Aviation Organisation, Committee on Aviation Environmental Protection) (e.g. **CAEP 2008**).

ADMS-Airport is an extension of ADMS-Urban; within this User Guide it is assumed that you have a copy of the ADMS-Urban User Guide and are familiar with ADMS-Urban. It is also assumed that you have a copy of the EMIT User Guide. Whilst EMIT is not essential for modelling airports using ADMS-Airport it will be very useful when modelling more complex airports. This User Guide takes the user through the whole process required for modelling air quality around an airport; from constructing an emissions inventory through to dispersion modelling using ADMS-Airport.

ADMS-Airport is supplied with the ADMS Mapper. The ADMS Mapper allows you to set up modelling scenarios visually using digital map data, CAD drawings and/or aerial photographs, display output concentrations such as contour plots and produce hard-copy presentation layouts. ADMS-Airport also contains links to the ArcGIS and MapInfo packages.

1.1.1 Principal features of ADMS-Airport

The system has a number of distinctive features which are summarised below and described in detail in the subsequent sections of the manual. These are:

- The modelling of aircraft jet sources as ***jets from an accelerating source*** to capture the near field plume rise and dispersion characteristics. These are referred to in this User Guide as ***Air File*** sources.
- ***Advanced dispersion model*** in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the surface. The 'local' Gaussian type model is nested within a trajectory model so that significant areas (e.g. 50 km × 50 km) may be considered.
- A ***full range of explicit source types – one Grid source containing up to 3000 cells***, ***500 Aircraft jet sources***, ***3000 Road sources*** and ***1500 Industrial point, line, area and volume sources*** can be modelled simultaneously. With the use of aggregation of smaller sources onto grid sources, this allows consideration of very large numbers of sources in model runs.
- The modelling of ***chemical reactions*** involving NO, NO_2 and ozone and generation of sulphate particles from SO_2
- Direct link to ***EMIT (Emissions Inventory Toolkit)***, which contains emission factors for various aircraft and other airport sources
- The calculation of emissions from traffic count data, using a database of ***up-to-date UK emission factors***
- A direct link to an ***Emissions Inventory database***
- An ***easy to use*** interactive graphical interface
- Integrated ***ADMS Mapper*** for visualising and editing input data and visualisation of model output.
- Integration with commercial ***GIS*** (***ArcGIS*** and ***MapInfo***)
- A ***meteorological pre-processor*** which calculates the boundary layer parameters from a variety of input data: e.g. wind speed, day, time and cloud cover, or wind speed, surface heat flux and boundary layer height. Meteorological data may be raw hourly values or statistically analysed.
- A ***non-Gaussian vertical profile of concentration*** in convective conditions, which allows for the skewed nature of turbulence within the atmospheric boundary layer that can lead to high surface concentrations near the source. This gives better performance in validation tests.
- An ability to incorporate ***detailed time-varying emissions***

1.1.2 Graphics

ADMS-Airport can produce contour plots of pollutant concentrations which may be overlaid onto digital map data within the ADMS Mapper, a GIS or in the plotting package Surfer. An X-Y plotting facility for concentration, deposition and plume parameters for a single point source is also included.

1.1.3 Output facilities

ADMS-Airport produces the majority of its numerical output in comma-separated variable text file format, which may be viewed in a spreadsheet package such as Microsoft Excel or in a text editor such as Windows Notepad.

1.2 Other documentation

In addition to this User Guide, there are other specification and validation documents available for ADMS-Airport and ADMS-Urban, e.g. **CERC** (2013), **Carruthers *et al*.** (1998, 2001), **McHugh *et al*.** (1997). All references are listed together in Section 10. Many of these documents can be downloaded from the CERC website www.cerc.co.uk/software-support/publications.html.

1.3 Setting up ADMS-Airport in Run Manager

Run Manager is a tool to help users manage their model runs and make the most of their CERC licence(s). Please contact CERC if you would like to purchase a Run Manager licence. Instructions for setting up ADMS-Airport as a model in Run Manager are included here for convenience.

Adding ADMS-Airport to the available models in Run Manager can be done using the **Models** screen. To view the **Models** screen in Run Manager, choose **Options > Global > Models** from the main menus, or use the keyboard shortcut (**Ctrl+M**).

To add a new model, click **<New Model>** at the end of the list of **Available Models** and complete the bottom half of the screen. **Figure 1.1** shows the standard settings for ADMS-Airport 3.4.

The standard required *.dll* files are automatically included after selecting the Executable using the top ... button. The ADMS-Airport licence file must also be added the list of required files. To add the licence file, or any other required files, click the middle ... button and browse to the files. To remove a file from the list, select the file in the **Required Files** list and press the **Delete** key on the keyboard.

The `/e2` and `/remote` Command Line Parameters are required to enable Run Manager to monitor the progress of an ADMS-Airport run, these parameters are

added by default. The `/ADMSAirport` parameter is also required and indicates that the model being used is ADMS-Airport. To add the `/ADMSAirport` parameter, or any other additional parameters, click the lower .. button and type the parameter. The parameters should be added individually, and can be added with or without the leading slash. To remove a parameter from the list, select the parameter in the list and press the **Delete** key on the keyboard.

The settings below will enable Run Manager to execute typical ADMS-Airport model runs. Advanced model users may wish to consult the model documentation for additional files and command line parameters for very specialised runs.

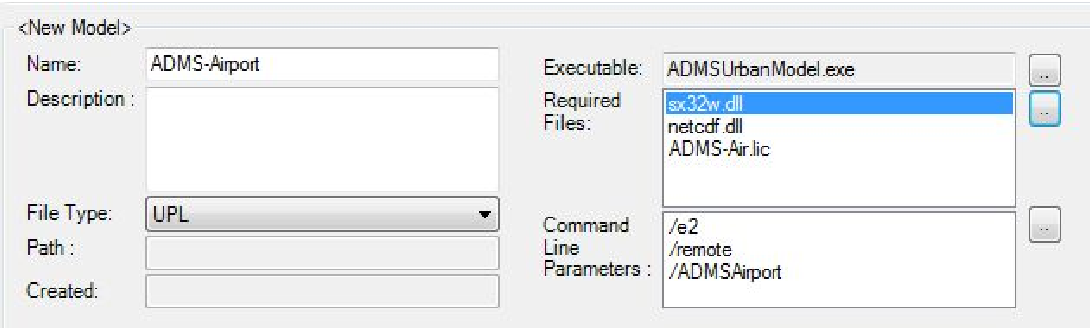


Figure 1.1 – Run Manager Model settings for ADMS-Airport 3.4.

Press **Save** to make the new model available for new runs. This can be checked using the **Add Runs** screen.

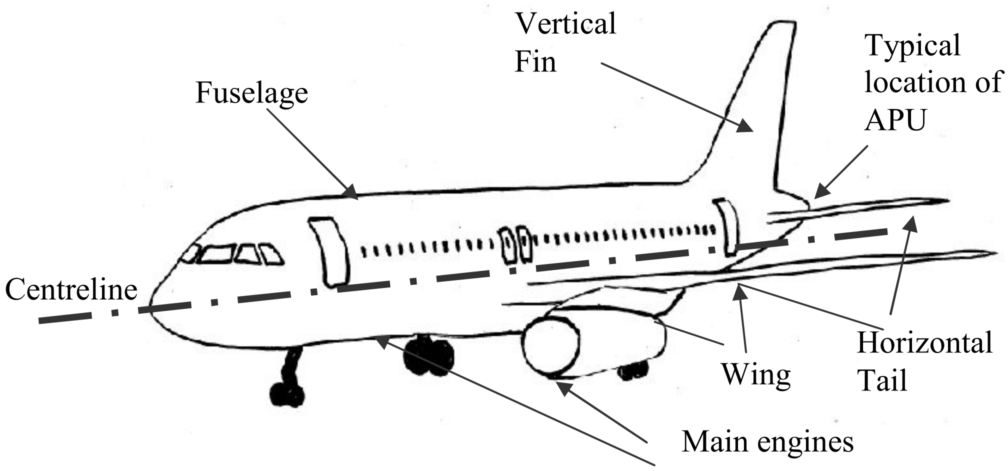
When the `/Remote` command line flag is used, as is standard when the model is run through Run Manager, the model will create an additional output file with the *.OK* extension, to indicate that the run has successfully completed.

SECTION 2 Introduction to Aircraft and Airports

This section describes aircraft and airport terminology used throughout this User Guide.

2.1 Aircraft

Figure 2.1 shows a diagram of an aircraft with some aircraft terminology described.



Aircraft terminology:

Fore	Front of aircraft
Aft	Rear of aircraft
Port	Left of aircraft (when viewed from the aft)
Starboard	Right of aircraft (when viewed from the aft)
Centreline	Central line of an aircraft, running from fore to aft
Fuselage	Aircraft body
Wing	Aircraft flight surface
Horizontal tail	Aircraft flight surface
Vertical tail	Aircraft flight surface
Main engines	Engines for propulsion
APU	Auxiliary power unit, engine for power on ground

Figure 2.1 – Diagram of an aircraft

Aircraft are often divided into three categories based on the type of engine installed; jets, turboprops and piston. Jet aircraft include aircraft with turbojet and turbofan engines. **Figure 2.2** shows examples of the different types of engine.

The bypass ratio (BPR) of an aircraft is the ratio of bypassed flow to core flow. **Figure 2.3** shows a diagram of a high bypass ratio jet engine.

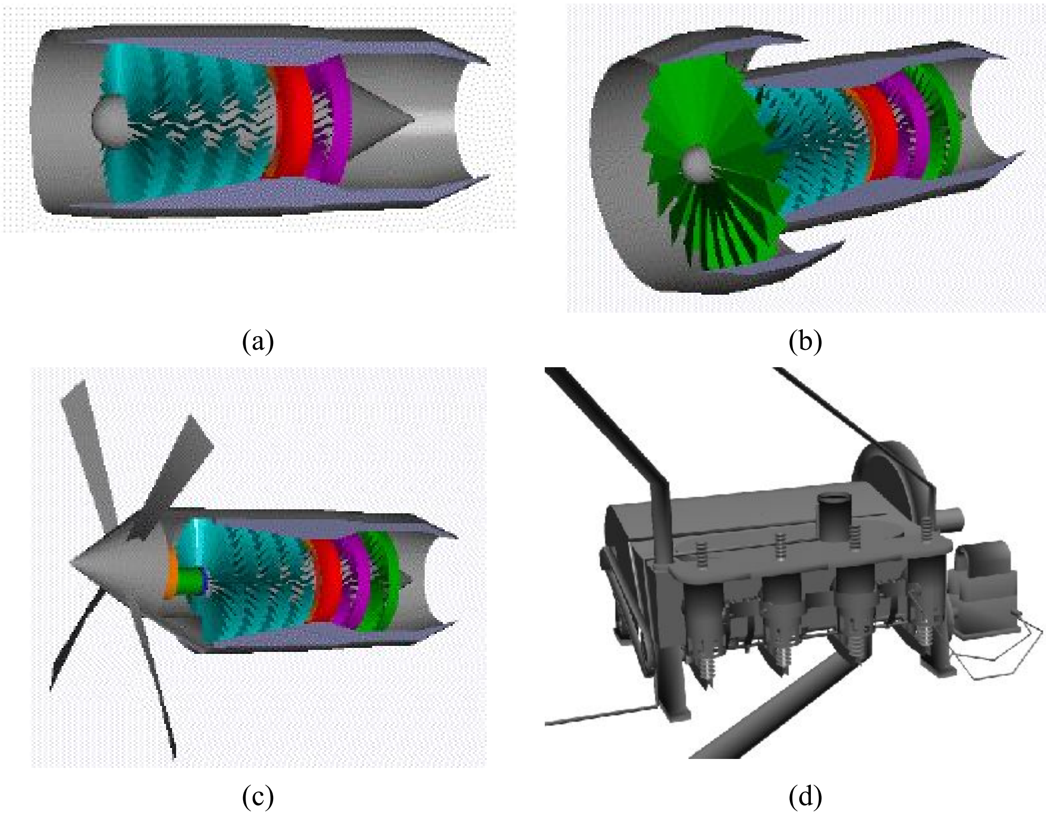


Figure 2.2 – Aircraft engine types (a) turbojet, (b) turbofan, (c) turboprop and (d) internal combustion engine (piston engine).
(taken from **NASA 2007**)

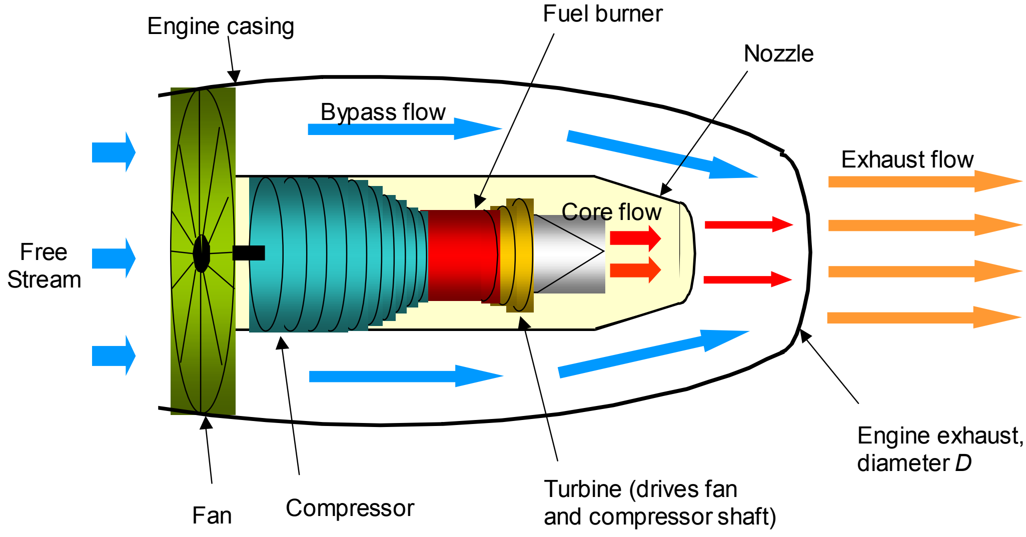


Figure 2.3 – Schematic diagram of the airflow through a high bypass ratio turbofan engine

2.2 Aircraft operations at an airport

Aircraft operations at an airport involve:

- arrival and departure of the aircraft, known as the landing take-off (LTO) cycle
- transfer of the aircraft between the runway and a stand (see Section 2.3)
- preparation of the aircraft for flight

The LTO cycle below 3000 feet is described in **Figure 2.4**. The LTO cycle can be split into 4 distinct modes; arrival at the airport involves approach and landing modes, whilst the departure from the airport involves take-off and climb modes. The aircraft arrival generally involves the aircraft approaching the airport at a constant angle of 3° below the horizontal sometimes referred to as a 3° glide slope. The aircraft climb from the airport can be further split into two modes; initial climb and climb out. The initial climb and climb out modes are separated by thrust cutback, where the thrust level of the main aircraft engines is reduced, this generally occurs at 1500 feet. The climb angles at which the aircraft depart the airport are dependent on the type of aircraft and operating weight, see Section 4.2.6 for further details. The distance from the departure airport to the destination airport is a good indication of the weight of the aircraft at take-off. The length of a flight is often referred to in terms of stage length, an integer number describing the aircraft trip length from stage length 1, a short trip, to stage length 8, a long trip.

The number of stage lengths an aircraft is able to complete will depend on the aircraft type. Some small aircraft types are only able to complete flights of stage length 1 and only the largest aircraft types are able to complete flights of stage length 8.

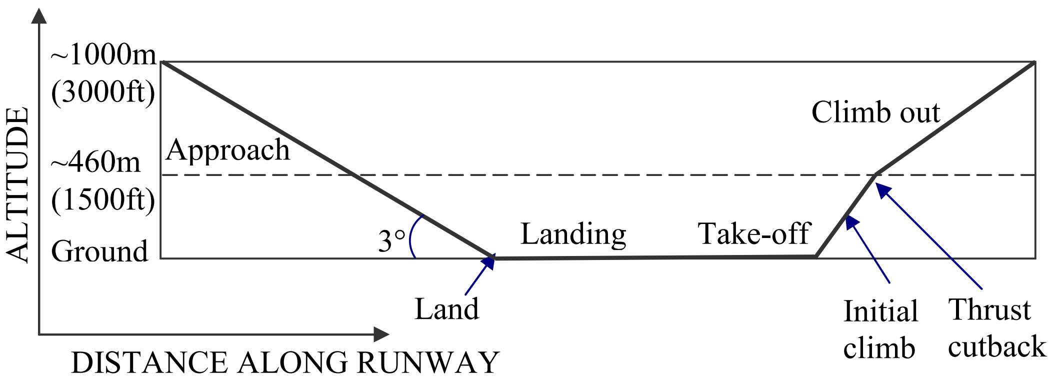


Figure 2.4 – Landing take-off cycle (LTO)

Transfer of the aircraft between the runway and the stand is known as taxiing (taxi mode).

Once the aircraft arrives at the stand the aircraft is turned around, that is, prepared for its next departure. This involves switching off the main engines, unloading of arriving passengers and/or cargo from the aircraft, possibly replacement of the aircraft crew, cleaning of the aircraft, aircraft refuelling, loading of departing passengers and/or cargo, starting of aircraft main engines and pushback from the

stand. Some of these functions involve operation of the aircraft APU (auxiliary power unit) and GSE (ground support equipment). The APU can provide the aircraft with electrical power, preconditioned air and bleed air for starting the main engines. GSE is used to describe a diverse range of vehicles and equipment for support of the aircraft. GSE may provide electrical power to the aircraft whilst at the stand, transfer passengers or cargo to/from the aircraft or service the aircraft during passenger/cargo unloading/loading. Pushback is where a piece of GSE, called a tug, is used to push the aircraft back from the stand.

2.3 Airport layout

Figure 2.5 shows an example layout of an airport, with **Table 2.1** providing a description of the terms used.

Airport Term	Description
Airside	Relating to activities inside the airport secure perimeter, e.g. airside roads – roads inside the airport secure perimeter
Landside	Relating to activities outside the airport secure perimeter, e.g. landside roads – roads outside the airport secure perimeter Taxi and bus stands are usually classed as landside
Runway	A path used for aircraft to take-off and land
Taxiway	A path connecting runways to hangars, terminals and other airport facilities
Apron	Area where aircraft are parked, unloaded or loaded, refueled or boarded
Stand	Area where aircraft passengers board and disembark
Pier stand	Stand connected to the airport terminal
Remote stand	Stand remote from the terminal
Fuel farm	Storage facility for fuel on the airport, i.e. aircraft fuel and GSE fuel
Fire training ground	Area where airport fire training activities take place
Engine run-up bay	Area where the running of aircraft engines takes place for engine test runs, normally has silencing screens to reduce the impact of the engine noise
De-icing pad	Area where aircraft undergo de-icing activities
Power plant	Power plant providing electrical and process energy to airport buildings

Table 2.1 – Airport emissions sources

The naming of runways follows a convention based on the runway magnetic heading, where the runway name is the nearest whole integer of the magnetic heading divided by 10. For example, a runway with magnetic heading 274° the runway name would be 27 and the runway in the opposite direction with magnetic heading 94° would be 09.

The magnetic heading is the heading relative to the magnetic north pole. The magnetic north pole moves slightly relative to the Earth's surface and as such the runway names can change over time.

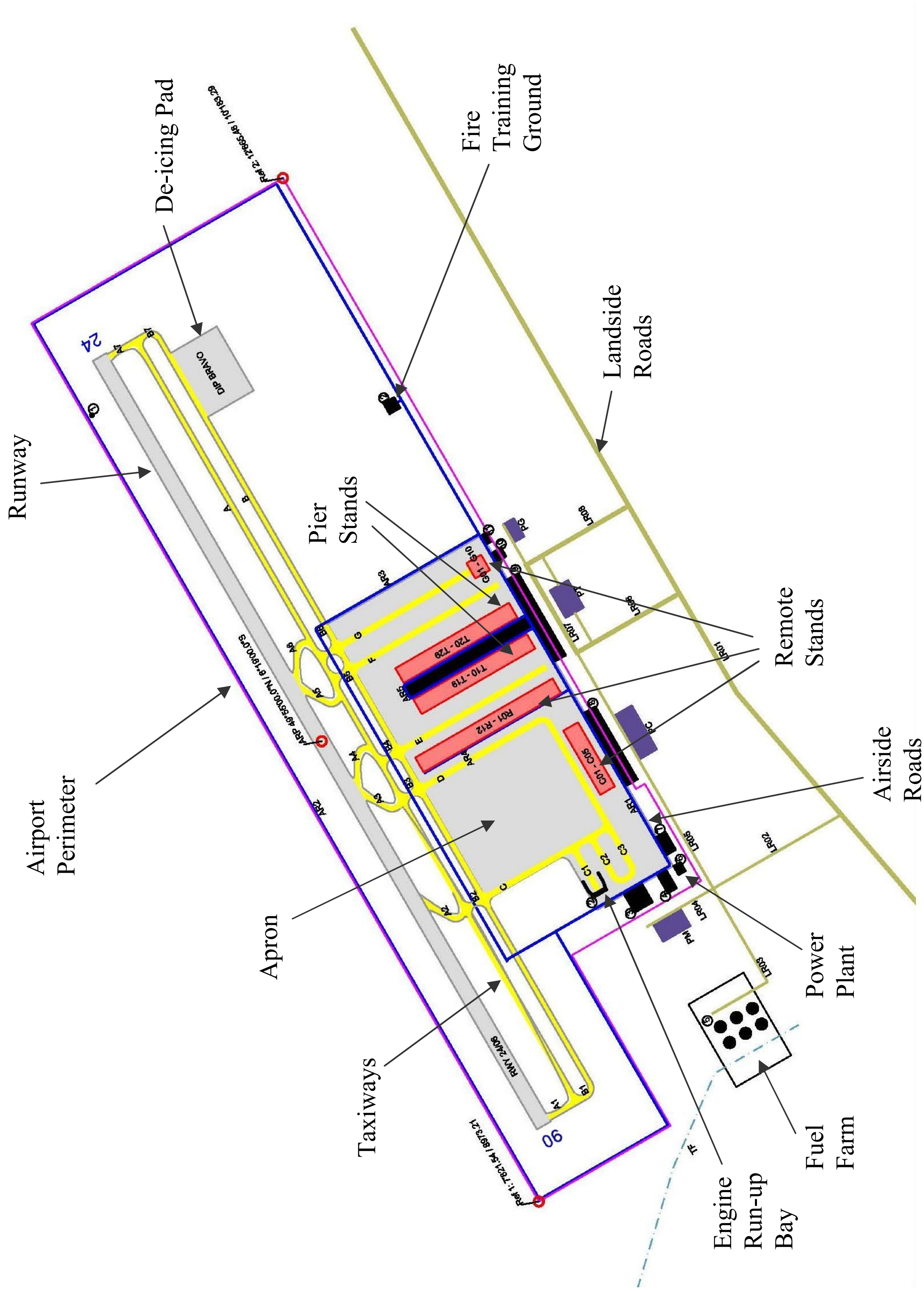


Figure 2.5 – Example airport layout (taken from **CAEP 2008**)

SECTION 3 Using ADMS-Airport to Model an Airport

This section describes the emission sources that may occur at an airport and the methods of modelling these sources using ADMS-Airport and EMIT.

Section 3.1 summarises the sources of emissions particular to an airport, and Section 3.2 gives more details of each source group. Emissions from aircraft vary with time, and so do the emissions from the associated Auxiliary Power Units and Ground Support Equipment. Details of the way these variations can be modelled in ADMS-Airport are given in Section 3.3.

The source exit conditions from aircraft engines dominate the local dispersion of pollutants, unlike the dispersion of emissions from, for example, a power station. Emissions from aircraft engines are released as a jet, at a high speed and at a high temperature. Section 3.4 describes the way in which jet sources are used by ADMS-Airport to represent the emissions from aircraft.

3.1 Introduction

Emission sources at an airport may include:

- Aircraft engine emissions from taxiing, take-off, approach and landing
- Aircraft Auxiliary Power Unit (APU) emissions
- Aircraft Ground Support Equipment (GSE) emissions
    - GSE operating at stands
    - GSE operating across the aprons
- Airport landside traffic source emissions
- Airport static source emissions, for example, power plants
- Emissions sources external to the airport, such as roads

All the above sources can be modelled in ADMS-Airport as explicit sources. In addition, a grid source can be created to account for emissions from sources that are within the airport but too small to be considered explicitly, and/or sources that are external to the airport and at a sufficient distance such that their local source properties are not significant.

3.2 Sources of Emissions

There are a number of elements used to represent emissions at an airport in ADMS-Airport. These include:

- Spatial allocation of emissions
- Magnitude of emissions
- Time-varying nature of emissions
- Aircraft exhaust dispersion characteristics (for **Air File** sources)

Table 3.1 presents emissions sources which may be included in a study of local air quality at an airport. The first column gives the source description, and the second column indicates whether or not the source of emissions is specific to the airport. The third column indicates how the source can be represented in ADMS-Airport.

Emissions Source	Emissions Source Specific to Airport?	ADMS-Airport Source Type
Aircraft arrival/departure	Yes	Volume or **Air File**
Aircraft Auxiliary Power Unit (APU)	Yes	Volume
Aircraft Ground Support Equipment (GSE)	Yes	Volume
Airport roads	Yes	Road or aggregated grid
Airport parking	Yes	Volume or area
Airport power plant	Yes	Point
Airport fuel farm	Yes	Area
Other airport activities, e.g. fire training, maintenance, aircraft engine testing, aircraft refuelling	Yes	Point, line, area, volume or aggregated grid
External road network	No	Road or aggregated grid
Other external sources, e.g. rail, boilers, commercial and domestic heating	No	Point, line, area, volume or aggregated grid

Table 3.1 – Airport emissions sources

For some scenarios, users may want to use a combination of ADMS-Airport source types for one particular source of emissions, for example, aircraft. Further discussion of the different ways in which aircraft can be represented is given in Section 3.2.1. For other source types, such as roads, significant sources close to the airport should be represented explicitly as road sources in the model run, whereas more distant road emissions can be aggregated into a grid source. Grid source emissions from roads and other sources can be calculated in EMIT (please refer to Section 8 of the EMIT User Guide), or in ArcGIS using the Emissions Inventory link (please refer to Section 6 in the ADMS-Urban & Roads ArcGIS Link document).

3.2.1 Aircraft engines

Aircraft emissions can be represented with varying levels of complexity depending on the available information. The level of complexity of modelling depends on:

- The detail of source data available, in terms of both the magnitude and spatial location of emissions, and
- The required resolution of concentration output.

Table 3.2 gives examples of methods for generating the magnitude of aircraft emissions data for use in ADMS-Airport at different levels of complexity.

Complexity Level	Description
Basic	**Calculate emissions using ICAO times in mode (ICAO 2007)** Use EMIT to generate an aircraft emissions inventory using ICAO17 + Other, ICAO 15 + Other, ICAO (Issue 13) 2005 or IPCC96 emissions factor datasets.
Medium	**Emissions available from inventory** Use a pre-generated emissions inventory
Complex	**Calculate emissions from flight performance model** Generate an aircraft emissions inventory based on aircraft operations considering factors such as the aircraft type, weight and engine installed.

Table 3.2 – Approaches to quantifying aircraft emissions

Table 3.3 summarises the different ways in which aircraft emissions can be represented spatially, ranging from the simplest approach to the most complex.

Complexity Level	Description
Basic	**Represent all aircraft emissions as a single volume source** Define all the aircraft sources or all the sources for each mode as a single volume source covering the area of emission up to a specified height above the ground.
Medium	**Represent the aircraft emissions as multiple volume sources** Define the aircraft sources as multiple volume sources, for example volume sources for each of taxiing, take-off, climb out, approach and landing.
Complex	**Represent the aircraft emissions as a combination of aircraft, volume, area and line sources** Define the aircraft sources as a combination of source types. For example take-off and landing as **Air File** sources, climb out and approach as volume sources and taxiing as line and area sources.

Table 3.3 – Methods of spatial allocation of aircraft emissions

When compiling aircraft emissions data, it is important to bear in mind the level of detail to which the magnitude, spatial distribution and time resolution of the emissions are defined and the level of complexity that the final output is expected to have. For example, if the emissions data have been calculated from basic fleet composition data, there may be little point using a complex spatial representation of the aircraft movements. Conversely, if for example, concentrations within the airport boundary are to be predicted in detail, then both emissions calculations and spatial representation of the sources should be detailed.

3.2.2 Aircraft Auxiliary Power Units

Aircraft auxiliary power units (APU) are on-board generators that generally provide electrical power, preconditioned air and bleed air for starting the main engines. APU emissions are generally attributed to the departure/arrival stands.

Some airports have facilities for providing these functions as a stationary system associated with the stand (there are no emissions local to the stand associated with electrical power) or as mobile equipment (GSE). The APU emissions should be reduced in line with the APU use, that is where GSE is being used to replace some of the APU functionality, then the APU emissions should be decreased accordingly.

APU emissions are usually modelled as volume sources. EMIT can be used to develop an aircraft APU emissions inventory.

3.2.3 Aircraft Ground Support Equipment

Aircraft ground support equipment (GSE) consist of a diverse range of vehicles and equipment for ground-based operations. GSE may provide electrical power to the aircraft at the stand, transfer passengers or equipment, and service the aircraft during passenger/cargo loading and unloading.

GSE can be split into two groups

- Sources at stand, for example ground power units (GPU)
- Mobile sources, for example crew buses

GSE emissions are usually modelled as volume sources. EMIT can be used to develop an aircraft GSE emissions inventory.

3.2.4 Airport Static Sources

Airport static sources may include power plant, any heating plant and a fuel farm. These can be modelled as point, line, area or volume sources within ADMS-Airport.

3.2.5 Urban Sources

Airports are often located in or near to an urban environment. Treatment of the sources external to the airport is as described in the ADMS-Urban User Guide.

3.3 Time-Varying Emissions

Emissions associated with an airport are subject to large variations with time. Variations may be:

- Diurnal (for example, there are usually more flights during the day than the night),
- Weekly (for example, business flights are more common on weekdays),
- Seasonal (for example, charter flights are busier at holiday periods), and
- Wind-direction dependent (aircraft *usually* take off into the prevailing wind)[1].

ADMS-Airport can model these variations if details are known, using hourly annual profiles (with the *.hfc* file), diurnal/monthly profiles or wind direction dependence (with the *.fac* file). In addition to aircraft emissions, APU and GSE emissions also vary with time; these variations can be modelled in the same way. **Table 3.4** summarises the way in which time-varying emissions can be modelled in ADMS-Airport, classified in terms of complexity.

Complexity Level	**Description**
Simple	**Continuous, diurnal or monthly profile** Use diurnal and monthly profiles to give simple operation trends using a *.fac* file. Full details are given in Section 7.3 of this User Guide.
Medium	**Based on wind direction** Aircraft operations generally[1] take-off and land into the prevailing wind. In this case the *.fac* file can be used to switch on sources for particular wind directions. Full details are given in Section 7.3 of this User Guide.
Complex	**Annual hourly emission profile** Describe the aircraft operation using an annual hourly emissions profile, *.hfc* file. This allows very detailed airport usage to be modelled. A full description of the *.hfc* file format is given in Section 7.4 of this User Guide.

Table 3.4 – Approaches to time-varying aircraft emissions

Further details of modelling time-varying emissions in ADMS-Airport are given in Section 5.2.2.

[1] Whilst this is usually the case, the operation of aircraft from particular runways may be subject to other factors, such as noise abatement restrictions. As such, the user should discuss the actual time-varying behaviour with the airport and aircraft operators.

3.4 Dispersion Modelling

As outlined in Section 3.2, the emissions sources in an airport can be realistically modelled as a combination of a number of source types, namely point, line, area, volume, road and **Air File** sources. The dispersion of emissions from all these source types is described in the Technical Specification, Section 9, of the ADMS-Urban User Guide, with the exception of **Air File** sources. The properties of **Air File** sources are detailed in Section 3.4.1 below, with technical details given in the Technical Summary, Section 7.1 of this User Guide.

3.4.1 Air File sources

Aircraft have a number of engines that emit a range of pollutants. The locations of these engines vary: some are wing-mounted and some fuselage-mounted. For example, if an aircraft has three engines the third will usually be mounted centrally on the fuselage at the base of the vertical fin. **Figure 3.1** shows some common locations of aircraft engines. In general the larger aircraft such as the Boeing 777 and Airbus A340, have at least two-wing-mounted engines and smaller aircraft, such as the Embraer 145, may have fuselage-mounted engines.

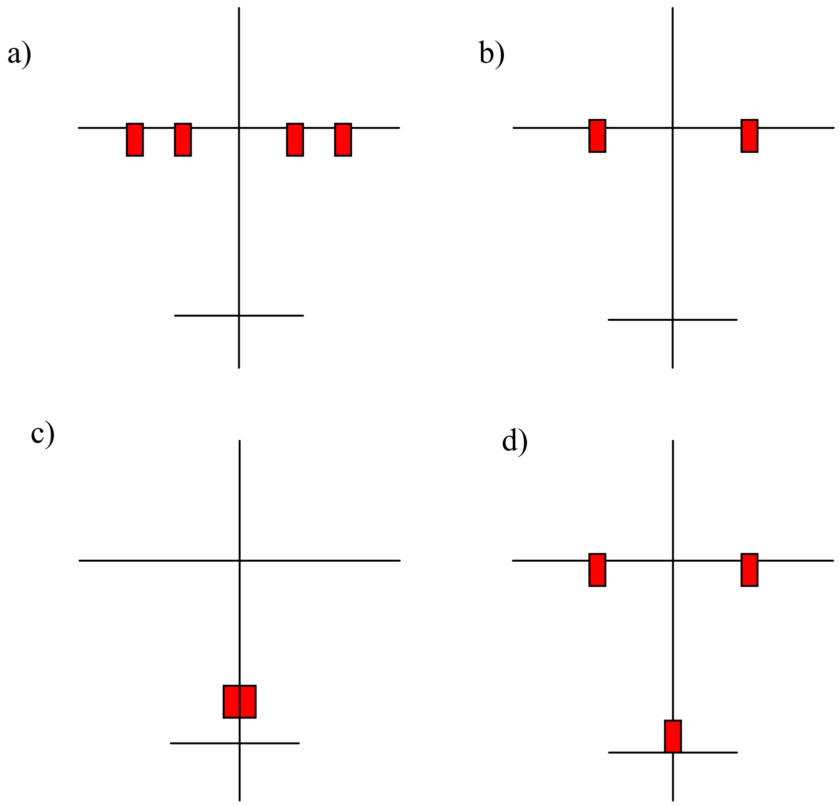


Figure 3.1 – Example locations of aircraft engines: a) 4 wing-mounted engines, e.g. Boeing 747, Airbus A340; b) 2 wing-mounted engines, e.g. Boeing 777, Airbus A320; c) 2 fuselage-mounted engines, e.g. Embraer 145; and d) 2 wing-mounted engines and one engine centrally mounted on the fuselage/vertical fin, e.g. McDonnell Douglas MD-11

In a complex dispersion model such as ADMS-Airport, each of these engines can be modelled separately. The best way to represent the aircraft engine exhaust conditions is as a moving jet source, as the emissions exit the moving engine at high speed. In the model, an **Air File** source consists of a series of continuous horizontal jet source releases, positioned to take account of the acceleration of the aircraft.

Engine properties

During a landing take-off (LTO) cycle the aircraft engine thrust setting varies according to the mode. Using the ICAO definition of thrust settings the aircraft during take-off operate at full thrust (100% thrust) and when climbing operate at 85% thrust. During approach the aircraft thrust setting is 30% and when aircraft are taxiing they operate at 7% thrust.

For each thrust setting, a particular engine has different source properties, which, in ADMS-Airport, are specified by the user. The source properties may be supplied by the aircraft manufacturers, or, if unavailable, may be estimated using some basic empirical algorithms outlined in Section 8.4.2 of this User Guide.

The aircraft exhaust conditions for a particular engine, at a particular thrust setting, are defined in the *.air* file. In this file, the engine properties are specified i.e.:

- Exit velocity;
- Exit temperature; and
- Engine diameter.

Further information required by the model includes the number of engines, and up to four engine locations; full details of how to set up the *.air* file are given in Section 7.1.

In general, the aircraft is modelled as moving at constant or zero acceleration. However, non-constant acceleration at take-off can also be modelled by use of an additional *.sec* file. For further details, please refer to Section 7.2.

***Air File** source properties*

In the **Air File** the user must assign a particular engine category to each **Air File** source. In addition, the source geometry must be given i.e. the start and end locations of the straight line along which the aircraft travels; further, the start and end aircraft speeds must be specified. For further details, please refer to Section 7.1.

Aircraft emissions

The emission rates for each **Air File** source are specified in units of g/s. For further details, please refer to Sections 4.2 and 7.1.

SECTION 4 Generating an Emissions Inventory

This section describes the methods used to generate an airport emissions inventory and building an inventory using the emissions inventory tool, EMIT. The complete emissions inventory can be stored in EMIT plus the **Air file**. The data in EMIT will be the magnitude and spatial information for emissions sources. The magnitude of the emissions may be calculated from emission factor datasets stored in EMIT and/or user-specified based on information supplied by the airport operator.

4.1 Introduction

An airport emissions inventory contains information regarding airport emissions including:

- the magnitude of emissions and
- the spatial allocation of the emissions.

Details of non-airport emissions, such as landside road emissions, may or may not be included in an airport emissions inventory.

Note the time-variability of the emissions is discussed in Section 5.2.2.

4.2 Aircraft Main Engines

The aircraft main engine emissions may be described with a varying degree of complexity in terms of emission quantity and emission spatial allocation. **Table 4.1** summarises the different approaches in terms of complexity. It is not always advisable to mix the levels of complexity when compiling an emissions inventory.

		Emission Quantity		
		Simple	**Intermediate**	**Complex**
Spatial Allocation	**Simple**	Section 4.2.3	!	!
	Intermediate	!	Section 4.2.4	!
	Complex	!	!	Section 4.2.5

Table 4.1 – Building an emissions inventory for aircraft main engines – degrees of complexity (! – the user should consider carefully using this approach, as there is a mixed level of complexity for spatial allocation and quantity of emissions)

Airport emissions inventories may be built using a combination of complexity levels for the emissions quantity and spatial allocation. However, careful consideration must be used when combining these different accuracy levels since increased accuracy in one area only may not lead to an overall improvement in accuracy.

4.2.1 Quantification of aircraft emissions

In order to describe the **quantity** of emissions from aircraft main engines, knowledge of the aircraft operations at the airport are required. Airport operators should be able to supply a list of aircraft movements, or an airport timetable.

It is important to be aware that **a particular airframe may have a number of possible engines installed**. As the engine installed on the aircraft may affect the aircraft emissions considerably in terms of dispersion of pollutants, the emissions **must** be specified in terms of the correct airframe-engine combination in the ICAO dataset.

For example, the Boeing 777-200 may have a number of different engines installed, including:

- General Electric GE90-76B, (ICAO identifier 2GE052)
- Pratt & Whitney PW4077, (ICAO identifier 2PW061)
- Rolls Royce Trent 877, (ICAO identifier 2RR025)

4.2.2 Landing Take-off cycle (LTO)

Figure 4.1 shows an example Landing Take-off (LTO) cycle, comprised of approach, taxiing (taxi-in and taxi-out), take-off and climb out modes. Emissions from each mode for each aircraft must be accounted for in the emissions inventory. In addition to the LTO cycle, the aircraft may spend some time with its engine on at the stand for pre- and post- flight maintenance checks; additional emissions should be included in the inventory to represent this.

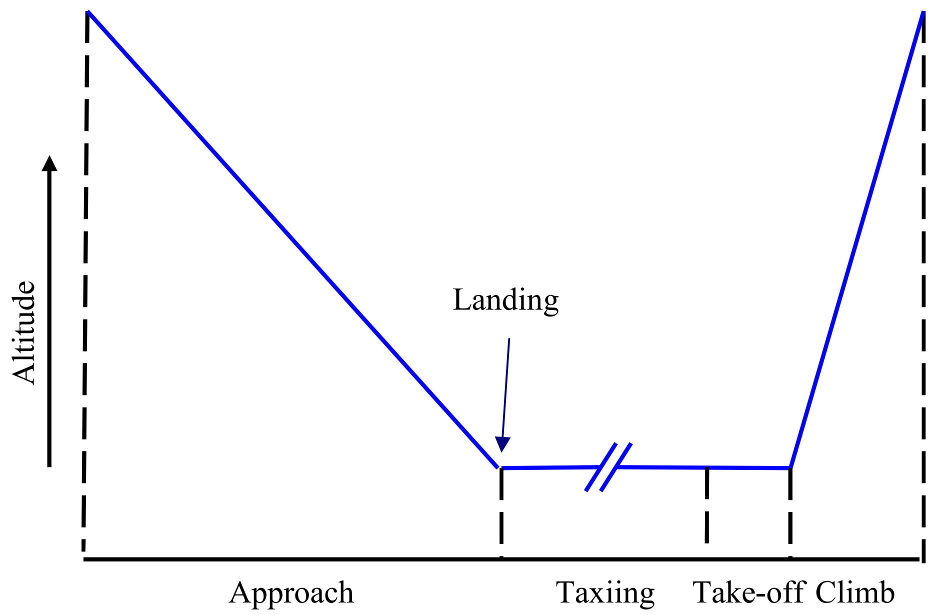


Figure 4.1 – Landing Take-off (LTO) Cycle, showing the different modes

4.2.3 Basic Scenario

Magnitude of emissions

One of the simplest approaches to quantifying emissions is to use a TIM (time in mode) approach. In order to generate emissions, this method combines:

- knowledge of the number of airframe-engine combinations arriving and departing the airport, with
- an estimate of the time spent by the aircraft in each mode and
- appropriate emissions factors, for example, **IPCC** (1996) and **ICAO** (2007).

The calculation of LTO emissions is as follows using the IPCC emissions factors dataset:

$$\mathrm{Emissions} = \mathrm{LTO}_{\mathrm{Domestic}} \times EI_{\mathrm{Domestic}} + \mathrm{LTO}_{\mathrm{International}} \times EI_{\mathrm{International}},$$

where:

$\mathbf{LTO_{Domestic}}$ – number of landings and take-off cycles of domestic flights

$\mathbf{EI_{Domestic}}$ – emission index for domestic flights

$\mathbf{LTO_{International}}$ – number of landings and take-off cycles of international flights

$\mathbf{EI_{International}}$ – emission index for international flights

The calculation is as follows using the ICAO emissions factors dataset:

$$\text{Emissions} = \sum_{i=0}^{n} \text{LTO}_i \times \left(\text{N}_i \times \sum_{j=0}^{3} \text{TIM}_{i,j} \times \text{EF}_{i,j} \right),$$

where:

i – airframe-engine type

j – aircraft mode (take-off, climb out, approach and taxi)

n – number of different airframe-engine types

$EF_{i,j}$ – emission factor for airframe-engine type i in mode j

LTO_i – number of landings and take-off cycles of airframe-engine type i

N_i – number of engines installed on a airframe-engine type i

$TIM_{i,j}$ – time in mode for airframe-engine type i in mode j

Tables 4.2 and **4.3** compare ICAO default TIMs to alternative TIMs for generic aircraft generic types (the latter taken from **US EPA** (1992)).

Aircraft Type	Aircraft Mode (Thrust Setting)			
	Approach (30%)	Taxi (7%)	Take-off[2] (100%)	Climb[2] (85%)
All	240	1560	42	132

Table 4.2 – Aircraft times in mode (s) – ICAO default

Aircraft Type	Aircraft Mode (Thrust Setting)			
	Approach (30%)	Taxi (7%)	Take-off[3] (100%)	Climb out[3] (85%)
Large Jet	240	1560	42	132
Medium Jet	240	1560	42	132
Small Jet	240	1560	42	132
Regional Jet	240	1560	42	132
Turboprop	270	1560	30	150
Business Jet	96	780	24	30
Piston	360	960	18	300

Table 4.3 – Aircraft times in mode (s) – US EPA

When compiling an emissions inventory using a particular dataset, it is important to be aware of any restrictions. For example, both the ICAO and

[2] Take-off represents from the start of the take-off roll to wheels off, climb represents wheels off to 3000ft
[3] Take-off represents from the start of the take-off roll to 1500ft, climb out represents 1500ft to 3000ft

IPCC aircraft emission factor datasets give emission factors for movements up to 914m (3000ft). For the ICAO dataset, the main engine emissions are split into ground sources (taxi and take-off), and elevated sources (approach and climb); conversely, the IPCC emissions are not categorised into different modes i.e. there is only one emission per LTO cycle for a particular airframe-engine type.

The simple emissions quantity calculation described above is also compatible with the intermediate complexity spatial allocation of emissions (Section 4.2.4).

Spatial allocation of emissions

The simplest method of distributing emissions from aircraft main engines would be to represent the emissions from each mode as separate volume sources, where the aircraft main engines are operating. The emissions from approach and climb out should be allocated to volume sources above the ground.

Using IPCC emission factors, modelling all the aircraft emissions as ground level sources would lead to an overestimate in ground emissions since the IPCC LTO emissions include emissions up to 914m (3000ft).

Using EMIT to generate an emissions inventory

There are five datasets available in EMIT for calculating emissions from aircraft main engines. The datasets available are described in **Table 4.4**.

Dataset Name	Includes emissions for:	Activity data
IPCC96 Air (average)	Average fleet	• Number of domestic and international LTO cycles • Fuel used during cruise for domestic and international flights
IPCC96 Air (old)	Old fleet	
ICAO (Issue 13) 2005	Jet engines with rated power greater than 26.7kN[4]	• Airframe-engine combination • Thrust for the aircraft mode • Number of LTO cycles for the aircraft-engine combination annually • TIM for a single flight
ICAO 15 + Other, ICAO 17 + Other	Jet engines with rated power greater than 26.7kN[4] Generic turboprops[5] Piston aircraft[6]	• Aircraft-engine combination • Thrust for the aircraft mode • Number of LTO cycles for the aircraft-engine combination annually • TIM for a single flight

Table 4.4 – EMIT datasets for aircraft main engine emissions.

If using an IPCC emission dataset to model air quality at an airport, cruise emissions should not be included, since cruise emissions tend to be released at high altitudes and will not affect the air quality at the ground.

In this basic scenario it is recommended that volume source groups should be set up for each mode considered i.e. two groups, one each of taxiing and take-off. Users might decide not to model approach and climb emissions if the contribution from these elevated sources on ground level concentrations is considered to be negligible. Note:

- Each runway should be a separate source within the take-off group.
- Each taxiway may be set up as a different source within the taxiing group, depending on the airport layout.

When using EMIT to calculate emissions of PM_{10} using datasets ***ICAO 15 + Other*** *or* ***ICAO 17 + Other*** *remember that for turboprop or piston engine aircraft PM_{10} emissions are not included in the dataset. Be particularly careful if using a combination of jet, turboprop and piston engine aircraft in the same group as PM_{10} emissions shown will be for the jet engines in the group only.*

[4] From the International Civil Aircraft Organisation (ICAO) aircraft emissions databank.
[5] Generic turboprop emissions were calculated from Swedish Defence Research Agency (FOI) held turboprop emissions database, based on 3 engine rated thrust levels below 1000 HP, 1000 HP to 2000 HP and above 2000 HP.
[6] From the Swiss Federal Office of Civil Aviation (FOCA) piston-powered aircraft emissions database.

4.2.4 Intermediate Scenario

Magnitude of emissions

Aircraft main engine emissions may be provided as an inventory from an external source, categorised by mode. The emissions supplied may be in greater detail than described in Section 4.2.3.

Spatial allocation of emission

The detail that can be represented in the spatial allocation of emissions will depend mostly on the information available. For a scenario of 'intermediate complexity' it is assumed that approximate departure and arrival paths of the aircraft are known. In this case, both the ground level and elevated aircraft emissions should be included in the emissions inventory.

The aircraft emissions can be represented as multiple volume sources. For example, **Table 4.5** shows how a typical LTO cycle could be represented. **Figure 4.2 a)** shows the LTO cycle in terms of five modes: approach, landing roll, take-off roll, initial climb and climb out. The figure indicates where the aircraft lands, and where the engine thrust is 'cutback' in the transition between initial climb (between the ground and 457m) and climb out (457m to 1000m). **Figure 4.2 b)** shows some example volume sources that would describe the different modes; these are summarised in **Table 4.5,** with some example dimensions. The width of each of the volume sources is dependent on the aircraft mode, and may require some local knowledge, for example details of the most commonly used flight paths. The length of the volume sources should be aircraft-dependent but the user might choose to use average lengths.

Aircraft Mode	Example source dimensions		
	Bottom of source (m above ground)	Top of source (m above ground)	Width (m)
Approach #1	457	1000	100
Approach #2	0	457	100
Landing roll	0	0	50
Take-off roll	0	0	50
Initial climb	0	457	160
Climb out	457	1000	160

Table 4.5 – Example volume source parameters

*It is advisable to split approach and climb into two or more volume sources, as indicated in **Table 4.5**.*

Using EMIT to generate an emissions inventory

Emissions data provided by external sources should be manipulated into a format compatible with EMIT input (*.csv*, *.shp*, *.mif*), using the required spatial detail; the data can then be imported into EMIT using the EMIT Import Wizard. Once the emissions data are in the EMIT database, the

emissions can be viewed using the EMIT GIS links to ArcGIS or MapInfo and imported into ADMS-Airport.

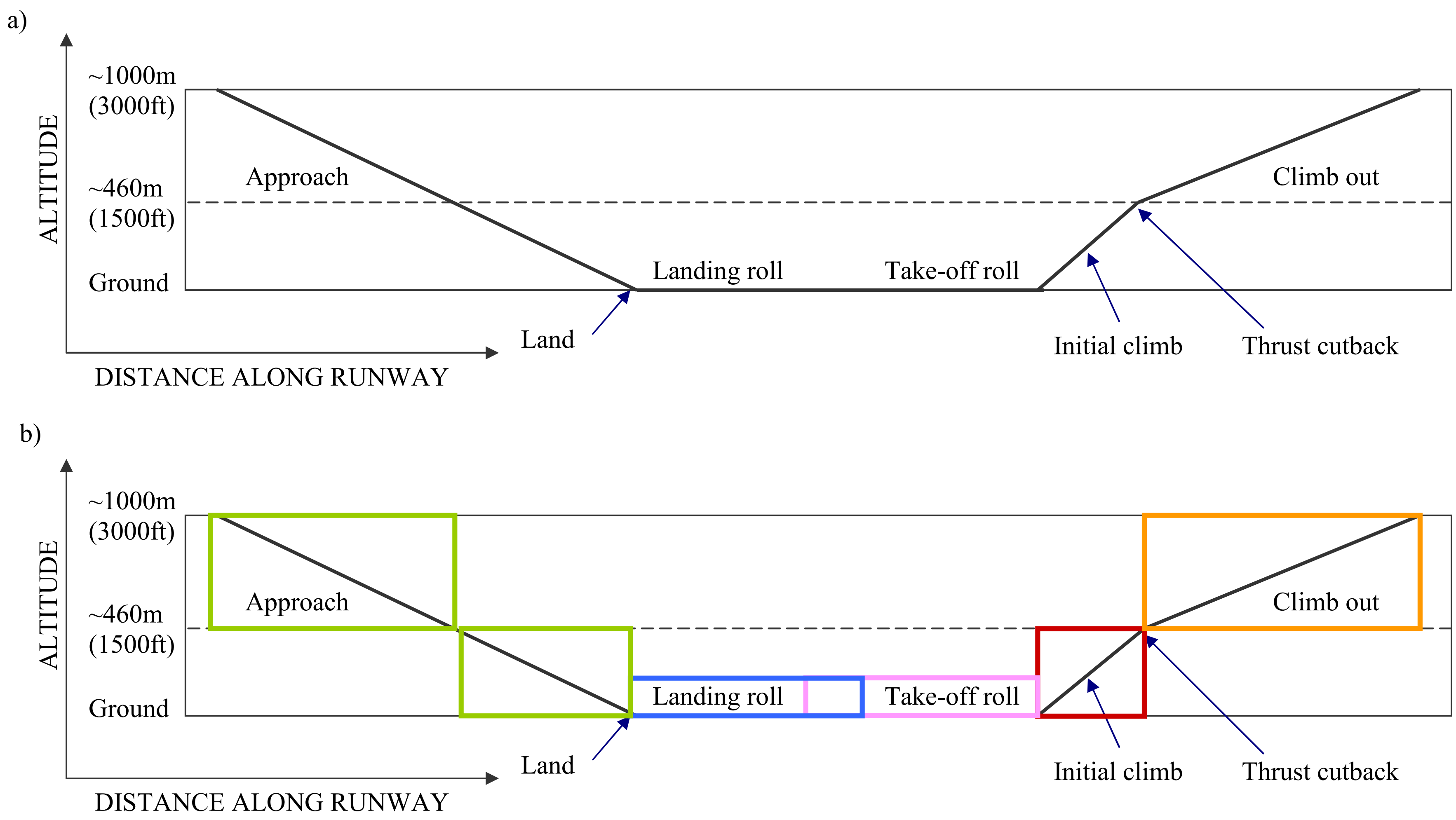


Figure 4.2 – Intermediate spatial allocation of emissions a) LTO cycle, b) LTO cycle with example volume sources overlaid

4.2.5 Complex Scenario

Magnitude of emissions

The most sophisticated approach to modelling aircraft emissions is to generate emissions based on the actual performance of each individual aircraft arriving at and departing from the airport. In this modelling approach, a trajectory path and engine power setting is calculated for each aircraft-engine combination and specific aircraft weight, allowing accurate calculation of emissions. Hence a more accurate TIM (time in mode) is known and the assumption that the aircraft power is set at a fixed level in a flight mode is not required.

Aircraft emissions generated using an aircraft performance approach (as outlined above) may correct for changes in atmospheric conditions with altitude to give more accurate emissions.

Spatial allocation of emission

In generating the aircraft emissions, an aircraft performance model will calculate the trajectory path of each aircraft-engine combination at a specific aircraft weight. Accordingly, very detailed information is available about the spatial allocation of emissions. These emissions could be expressed as volume sources, **however ADMS-Airport incorporates a new type of emission source specifically for this purpose called an Air File source**.

*Using ADMS-Airport **Air File** sources*

Air File sources cannot be input into ADMS-Airport via EMIT and must be input directly into ADMS-Airport. **Air File** sources are input using an *.air* file uploaded to ADMS-Airport from the user interface via the **Source** tab, with **Aircraft Sources** selected from the dropdown menu.

Describing one or more of the aircraft modes as an **Air File** source means that ADMS-Airport will accurately model the emissions from the aircraft engines as a moving jet, as outlined in Section 3.4.1.

A full description of the *.air* file is available in Section 7.1.1.

4.2.6 Compiling Air File source data

There is a large range of aircraft at most airports. If a detailed methodology has been used to calculate the quantity and spatial allocation of emissions at a particular airport, then significant emissions data will have been generated. In contrast to the basic volume source approach, where emissions are aggregated together, modelling aircraft trajectories as **Air File** sources means that each particular aircraft trajectory can be modelled. However, in terms of data quantities, and model run times, the number of **Air File** sources may become restrictive if every aircraft movement is modelled separately.

For example, consider an airport with 250 movements per day. It may be appropriate to model at least the landing, take-off and initial climb modes as separate **Air File** sources (leaving approach and climb out as volume sources), and each aircraft may have up to 7 weight categories. If only one runway is considered with take-offs in two directions (i.e. into the wind), then this leads to up to $250 \times 3 \times 7 \times 2 = 10500$ different sources that could, in theory, be modelled separately.

In order to reduce the number of sources modelled, some categorisation of aircraft type and mode is necessary during the compilation of the emissions inventory. Example aircraft types are:

- Aircraft size (for example, small, medium, large)
- Engine type (for example, the different engines in the Boeing 777-200 listed in Section 4.2.1)
- Engine distributions (for example 2 wing-mounted, 4 wing-mounted, 2 fuselage-mounted – refer to Section 3.4.1)
- Engine technology (for example old, current, new)

Once the aircraft have been binned into a number of different types, say $N_{AirTypes}$, each type should be split into the different modes (N_{Modes}) that are to be modelled as **Air File** sources, for example: landing, take-off and initial climb. This leads to $N_{AirTypes} \times N_{Modes}$ different categories.

It is necessary to associate an engine location, diameter, exhaust velocity and temperature with each category. These may be averaged or example values taken from the range of aircraft within each category, or, in the absence of any other available data, some engine parameters may be estimated using the algorithms given in Section 8.4.

Once the aircraft have been binned into a number of categories (usually up to about 50 categories is sufficient for modelling most airports), it is then necessary to consider the following within each category:

- Aircraft weights (for example, ‘Stage 1’ for short-distance flights, ‘Stage 2’ for longer distance flights etc) and
- Runway usage (for example, take-offs being into the wind).

The combination of:

Number of aircraft categories	×	Aircraft weights	×	Runway usage

defines the number of entries in the *.air* file. Further details are given below.

For each aircraft type, the take-off speed and time to achieve take-off speed varies with aircraft weight. **Figure 4.3** shows two example LTO cycle trajectories for the same aircraft – one for a shorter distance 'Stage 1' flight, with less fuel on board, and one a longer distance 'Stage 2' flight, with more fuel. As the take-off, initial climb and climb out modes have different locations, they have to be modelled as different sources i.e. they are different entries in the *.air* file.

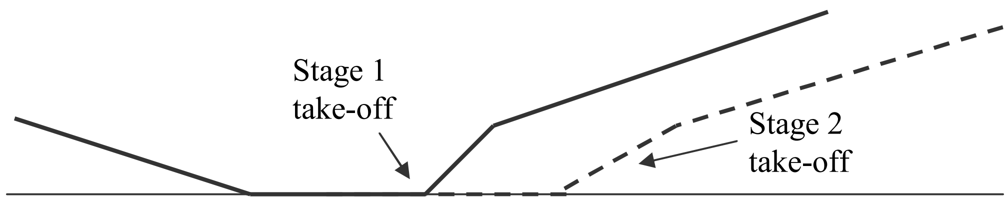


Figure 4.3 – Example trajectories for aircraft with different weights

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*The term **Stage** is used to denote the length of the trip an aircraft is completing on departure, i.e. stage 1 refers to a short trip length and stage 2 refers to a longer trip length.*

Further, it is clear that LTO cycles in one direction on a runway must be treated as a different source from LTO cycles in the opposite direction.

Finally, it is important to consider the time-varying nature of the emissions from the aircraft, which are modelled in ADMS-Airport by use of an *.hfc* file (further details given in Section 7.4). There are usually a number of movements within a particular aircraft/weight category. A choice must be made as to whether to treat each movement separately, or to average out the movements over a number of aircraft. It is quite common to:

- Treat the majority of the take-off **Air File** sources separately in terms of aircraft weights, and consequently representation in the *.hfc* file,
- Average the landing/climb out **Air File** source movements, and
- Average movements from sources with lower emissions (for example, smaller aircraft).

The simplification of the landing and climb out movements is motivated by the fact that the emissions from these modes are elevated from the ground. However, clearly, the above assumptions are emission-inventory dependent and it is important to consider whether such simplifications are appropriate for a particular modelling study.

*Note on output from ADMS-Airport when modelling **Air File** sources*

If contoured concentration plots are required as output from the model run, then, with regard to the **Source-oriented grids (Road, Line, Aircraft)** output option, it is important to be aware of the following:

By default, when the **Source oriented grids (Road, Line, Aircraft)** *output option is selected, additional output receptors will be placed along all* ***Air File*** *sources. If a number of* ***Air File*** *sources are modelled with overlapping locations, too many source oriented gridding receptors may be added. In order to avoid this, it is possible to include a list of* ***Air File*** *sources to which source-oriented gridding output points will be assigned in the .igp file. IGP stands for Intelligent Grid Points. Further details are given in Section 5.3.*

4.3 Aircraft Auxiliary Power Units

An aircraft auxiliary power unit (APU) is a gas turbine engine, usually mounted at the rear of the aircraft. The APU may be used to:

- Provide power for aircraft systems whilst the aircraft is on the ground,
- Provide air to the air conditioning system whilst on the ground,
- Provide bleed air for starting the main engines and;
- Provide a backup to the electric and hydraulic systems during taxiing and take-off or whilst in flight.

4.3.1 Magnitude of emissions

Each aircraft type is fitted with a particular type of APU. Therefore, working from a list of aircraft movements, the number of each type of APU can be determined. The amount of time the APU operates may depend on the aircraft type and the equipment available on stand or as GSE at the airport. Using the APU type, operation time and APU emission factors, emissions from the APU can be determined.

If equipment is available at the airport to replace or reduce the load on the aircraft APUs, operating times should be adjusted accordingly.

4.3.2 Spatial allocation of emissions

APU emissions are generally emitted when the aircraft is on stand. There may however be emissions when the aircraft is taxiing or in the first and last stages of flight.

4.3.3 Using EMIT to generate an emissions inventory

EMIT includes an emission factor dataset for APU emissions called APU 2004. In order to calculate aircraft APU emissions, a volume source group should be created, and sources for each stand (or groups of stands) should be

defined, with associated spatial information. The type of APU and annual operating time can be entered for each APU.

4.4 Aircraft Ground Support Equipment

Airport ground support equipment (GSE) comprises a diverse range of vehicles and equipment necessary to service aircraft during passenger and cargo loading and unloading, maintenance, and other ground-based operations. The wide range of activities associated with aircraft ground operations leads to an equally diverse fleet of GSE, each component of which has its own emissions performance and activity characteristics. For example, activities undertaken during a typical aircraft gate period include: cargo loading and unloading, passenger loading and unloading, potable water storage, lavatory waste tank drainage, aircraft refuelling, engine and fuselage examination and maintenance, and food and beverage catering. Airlines employ specially designed GSE to support all these operations. Moreover, electrical power and conditioned air are generally required throughout gate operational periods for both passenger comfort and safety, and often these services are also provided by GSE.

Mobile GSE that operate mainly on airside roads are sometimes referred to as airside vehicles, these are also categorised as GSE and include vehicles such as cars and buses.

4.4.1 Magnitude of emissions

The quantity of GSE emissions is usually calculated through assessment of the use of fuel for GSE or by estimating the operation time for each piece of GSE, and applying average emission factors, such as those included in EMIT for road vehicles.

4.4.2 Spatial allocation of emission

Some GSE operate mainly at the stands, some operate mainly on the airside roads, whilst others operate on a combination of stand and airside roads. The spatial allocation should reflect the usage of the equipment according to the particular airport being modelled.

4.4.3 Using EMIT to generate an emissions inventory

When calculating emissions from GSE using EMIT, it is advisable to split the sources into two groups: those that operate mainly at the stand (Static GSE) and those that operate mainly on the airside roads (Mobile GSE or airside vehicles).

EMIT includes an emission factor dataset for emissions from GSE operating at stands called AIRPORT GSE 2007. In EMIT, a volume source group for airport GSE should be created, and sources for each stand (or groups of stands) should be defined, with associated spatial information. The GSE operating at the stands and annual operating times for each GSE defined can then be entered.

When modelling airside vehicles, use standard road traffic emission datasets such as EURO 2009 Urban, EURO 2009 Rural, EURO 2009 Mway or EFT v5.2. In EMIT, a source group for Airside Vehicles should be created, and the airside road network should be defined with appropriate spatial information. Route types that reflect the mix of vehicle types on the airside roads should be defined, and source data such as vehicle speeds and traffic flows can be entered.

4.5 Airport Static Sources

Airport static sources may include sources that are specific to airports, such as training fires, in addition to those that are very similar to those found in non-airport locations, for example heating plants. These latter sources should be modelled as described in the ADMS-Urban User Guide, with emissions calculations performed in EMIT if required. Calculation of emissions from two airport-specific sources: a fuel farm and training fires are described in more detail below.

4.5.1 Magnitude of emissions

A fuel farm is used to store fuel used across the airport, typically including aviation fuel and diesel. Fuel farms produce evaporative emissions from the storage tanks. The US Environmental Protection Agency AP 42 documentation (**US EPA 1995**) contains a methodology for calculating evaporative emissions from organic liquid storage tanks.

Airport fire training involves the burning of fuel as an accelerant for training purposes. Emissions will depend on the type and quantity of fuel burned.

4.5.2 Using EMIT to generate an emissions inventory

Define the fuel farm as an area source with appropriate spatial and emission information.

Define the airport fire training area as a volume source with appropriate spatial and emission information.

4.6 Urban Sources

Non-airport emission sources close enough to the airport to require explicit modelling (such as major road and industrial sources) should be modelled as described in the ADMS-Urban User Guide, with emissions calculations performed in EMIT if required. Emissions from smaller sources, either within the airport or outside, may be aggregated in EMIT onto a grid of regular volume sources and modelled in ADMS-Urban as a grid source; details are again in the ADMS-Urban User Guide.

4.7 The Complete Emissions Inventory

Your complete emissions inventory should contain the magnitude and spatial distribution data for all the airport and surrounding sources except the data on aircraft sources that will be modelled using the **Air File**. The emissions data described in the **Air File** is not repeated in the EMIT database.

The final stage of compiling your inventory in EMIT is to aggregate all the emissions on to a grid source. A grid source will usually be used in ADMS-Urban and ADMS-Airport if the Trajectory model chemistry is to be used for modelling NO_x chemistry over large areas, and/or if some of the sources in the inventory are not going to be modelled explicitly. The grid sources calculated by EMIT containing the total emissions can then be exported to ADMS-Airport using the **Export Totals** button (Section 8.3.2 of the EMIT User Guide). Sources held in EMIT to be modelled explicitly in ADMS-Airport should be exported to ADMS-Airport using the **Export Group** button (Section 8.3.1 of the EMIT User Guide). Aircraft emissions that will be modelled as moving jet sources are entered into ADMS-Airport using the **Air File**.

The grid source total emissions exported from EMIT and imported into ADMS-Airport must not include the Air File emissions. Whilst industrial and road sources defined explicitly in ADMS-Airport are subtracted from the grid totals during the calculation, the Air File source emissions are not. If Air File source emissions are included in the grid totals in error, there will be a double-counting of emissions.

SECTION 5 Entering Emissions data into ADMS-Airport

5.1 Introduction

The **Setup**, **Meteorology**, **Background**, **Grids** and **Output** screens of the ADMS-Airport interface are identical to the corresponding screens in ADMS-Urban, described in Section 3 of the ADMS-Urban User Guide. The ADMS-Airport **Source** screen is described in Section 5.2 of this user guide and methods to incorporate the airport emission sources are described in Section 4.

Source-oriented gridding can be selected to enhance resolution around areas with high concentration gradients such as aircraft jet sources and roads. The additional functionality from ADMS-Urban to enable source-oriented gridding of aircraft jet sources is described in this section.

A large number of emission sources are often included in a single run when setting up a dispersion model of an airport. For this reason, it is useful to view sources within the ADMS Mapper prior to running the model, in order to check that the sources have been positioned correctly. The ADMS Mapper is also a useful tool for checking other source properties, such as relative magnitude of emissions.

5.2 The ADMS-Airport source screen

Figure 5.1 shows the ADMS-Airport source screen.

Aircraft sources are relatively complex because the emissions from engines vary significantly with the different thrust settings associated with take-off, climb out, approach and taxiing. A large number of aircraft types may have to be considered when modelling an airport, and each aircraft engine type has different source properties. For this reason the aircraft source data are compiled in a separate *.air* file, rather than being entered directly into the interface; details of the *.air* file are given in Section 7.1, including file format.

To model aircraft in ADMS-Airport, check **Model aircraft sources** on the source screen. The interface has a **Browse** button that allows users to link the appropriate *.air* file to the *.upl* file. Once the *.air* file has been selected, the source table is populated with all the **Air File** sources included in the chosen file. The source table displays the source name, and locations of the start and end of the source. In addition:

- a **View** button opens the *.air* file in your chosen file viewer, and
- a **Refresh** button updates the contents of the source table, to reflect any changes that may have been made to the *.air* file.

Non-constant emissions of pollutants can be represented using speed-emission curves. ADMS-Airport can model these variations, if the relevant data are known by the user. The speed-emission curve data are held in a *.sec* file, and details of the file format are given in Section 7.2.1.

To model speed-emission curves, check **Use speed-emission file** on the source screen. The interface has a **Browse** button that allows users to link the appropriate *.sec* file to the *.upl* file. In addition, a **View** button opens the *.sec* file in your chosen file viewer.

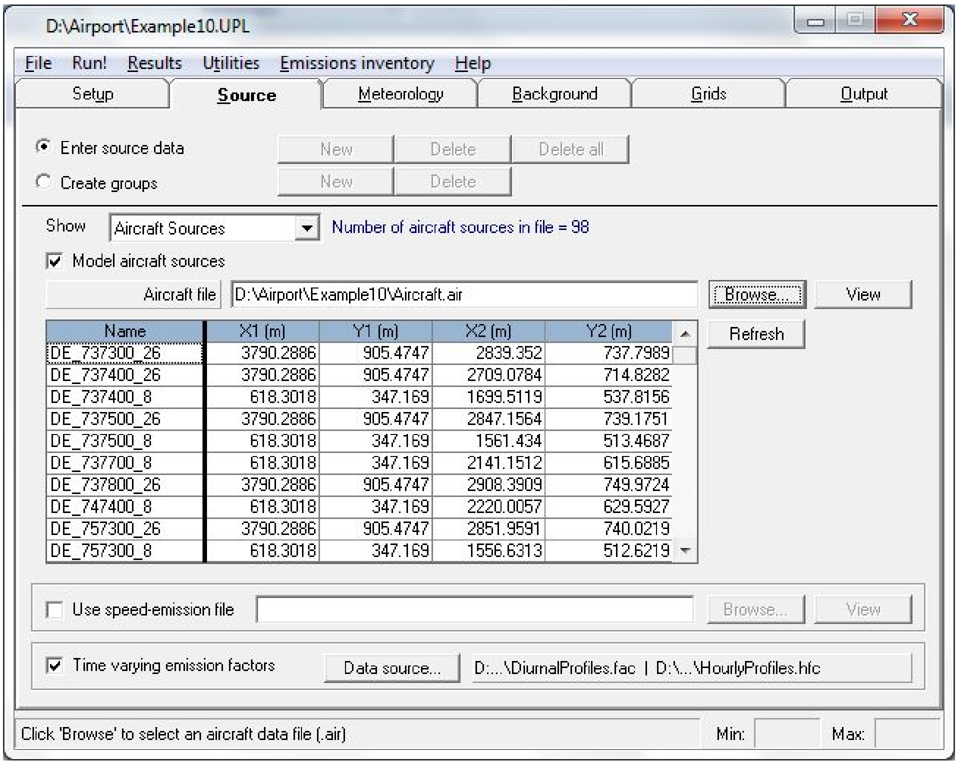


Figure 5.1 – The **Source** screen

Time-varying emissions factors for aircraft can be entered directly into the interface, via a *.fac* file and/or an *.hfc* file. If time-varying emissions factors are being used, check the **Time varying emission factors** box, and browse to locate the appropriate file(s) or enter the values in the table. For further details of time-varying emission factors and how to set up these files, please refer to Section 5.2.2.

Once aircraft source data have been entered, it is straightforward to enter road, grid and industrial source data by selecting the appropriate source type from the drop-down menu, as shown in **Figure 5.2**. Please refer to the ADMS-Urban User Guide, Section 3 for further details.

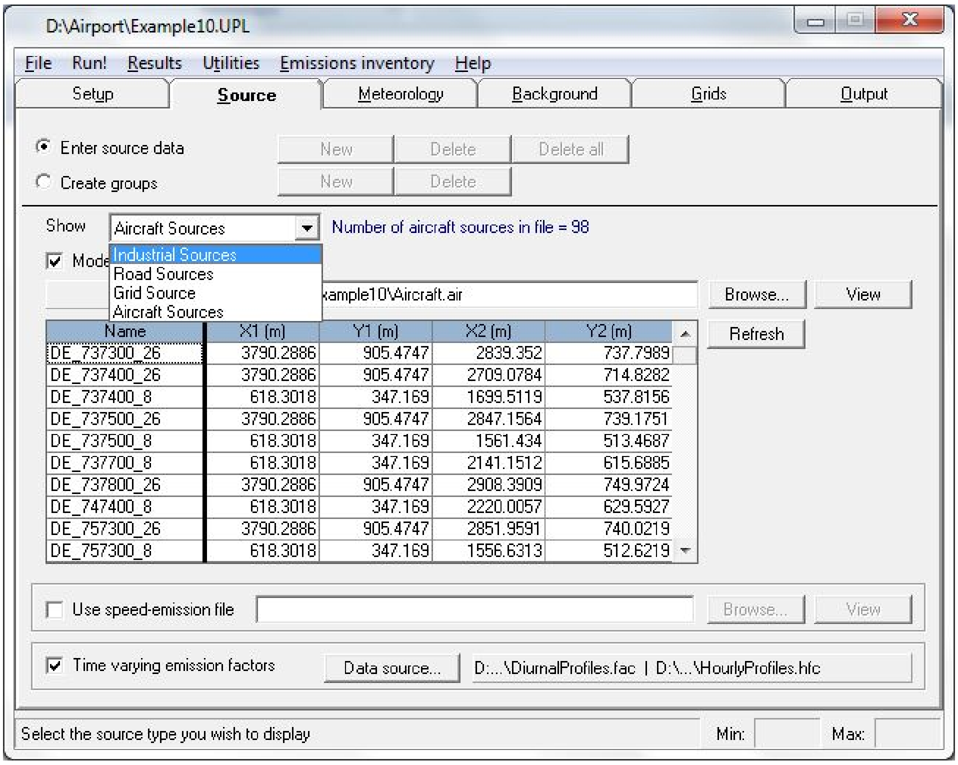


Figure 5.2 – Selecting other source types

5.2.1 Airport Sources

Table 5.1 shows the ADMS-Airport source types typically used with airport emission sources, as described in Section 3.

Airport Source	**ADMS-Airport Source Type**						
	Air File	**Road**	**Point**	**Line**	**Area**	**Volume**	**Grid**
Aircraft main engines	✓	✗	✗	✗	✗	✓	✗
Aircraft APU	✗	✗	✗	✗	✗	✓	✗
Aircraft GSE	✗	✓	✗	✗	✗	✓	✓
Airport static sources	✗	✓	✓	✓	✓	✓	✓
Urban Sources	✗	✓	✓	✓	✓	✓	✓

Table 5.1 – Typical use of ADMS-Airport source types

The **Air File** sources allow aircraft emissions to be modelled as moving jet sources. **Air File** sources are input using an *.air* file. The road, point, line, area, volume and grid source types are described in the ADMS-Urban User Guide in Section 3.

.air file

Air file sources describe aircraft engine emissions as moving jet sources. The **Air File** contains aircraft engine exhaust parameters and aircraft sources referencing the aircraft exhaust parameters. For the full **Air File** format see

Section 7.1. **Figure 5.3** shows how to select an *.air* file in the interface. A maximum of 500 **Air File** sources can be entered.

All sources entered into the *.air* file are assumed to have constant acceleration and a constant emission rate unless a variable acceleration and emission rate is specified using speed and emissions curves entered using a *.sec* file.

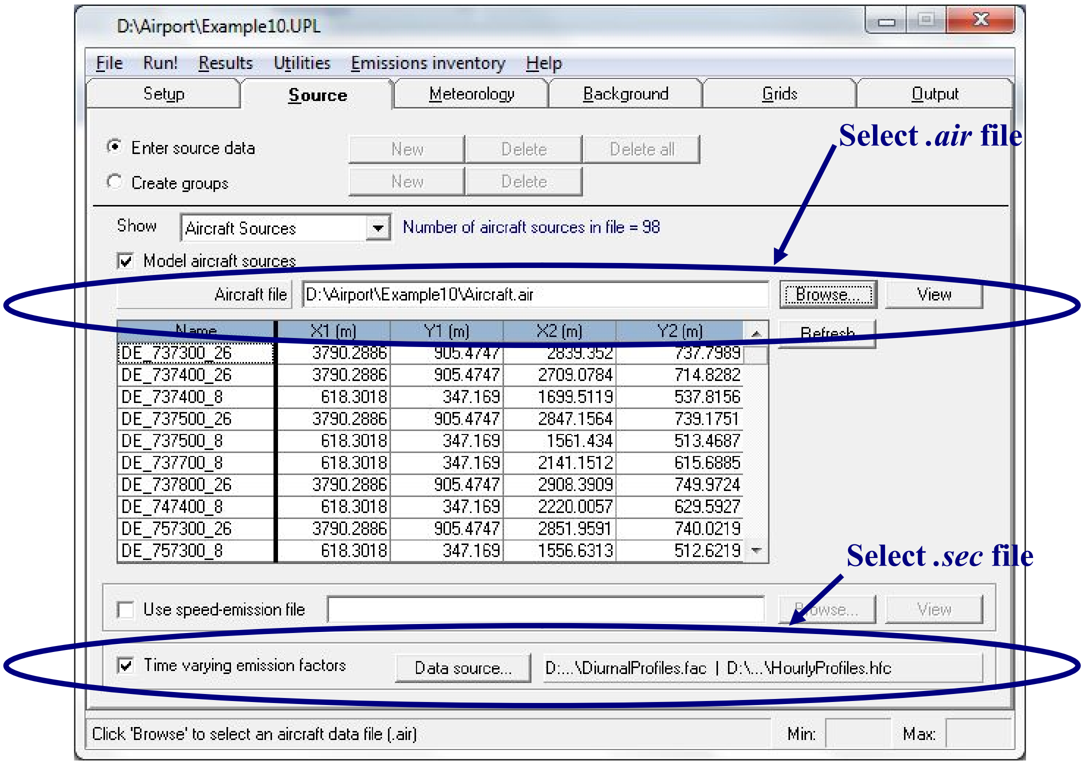


Figure 5.3 Selecting an *.air* and *.sec* file

.sec file

A *.sec* file is a *comma-separated* file used to apply speed and emissions curves to take-off emissions. **Figure 5.3** shows how to select a *.sec* file in the interface. The *.log* file reports whether a *.sec* file has been used in a model run. For the full *.sec* file format see Section 7.2.

The *.sec* file gives detailed information about how the aircraft speed and emissions vary along the runway and would be supplied by the airport or aircraft operators where required.

5.2.2 Time-varying Emissions

Depending on the complexity of the modelling and the available emissions data, time-varying emissions for aircraft sources can be approached in various different ways. A simple diurnal profile can be applied to all aircraft sources using the factors entered directly into the interface. Diurnal and monthly profiles can be applied using a *.fac* file. It can also be used to apply profiles based on wind direction, as aircraft will usually take-off and land into the

wind. More detailed profiles based on annual hourly emissions can be applied using *.hfc* files.

Table 5.2 summarises the various ways in which the time-varying emissions data can be entered into the model. Note that:

- Only one set of factors can be entered into the interface and this applies to all sources of the selected types.
- A *.fac* file and an *.hfc* can be used together in the same run.
- Sources may be entered in the *.fac* or the *.hfc* file, but not both.
- If time-varying emissions data for road and grid sources are entered via the interface, neither a *.fac* nor an *.hfc* file can be used.
- A 'default road' profile may be entered via the *.fac* file (please refer to Section 4.1 of the ADMS-Urban User Guide for further details of the *.fac* file).

Source Type	**Time-varying emissions data entered via the:**		
	***.fac* file**	***.hfc* file**	**Interface**
Aircraft	✓	✓	✓
Road	✓	✓	✓
Industrial	✓	✓	✓
Grid	✓	✗	✓

Table 5.2 – Time-varying emissions options for different source types

A 'default road' profile can be entered in the .fac file. This profile will then be used to vary the emissions from ***all*** *road sources unless a road source is explicitly defined as using another profile in either the .fac or .hfc files.*

.fac file

For simple time-varying emissions, monthly and diurnal profiles can be applied to aircraft emissions using a *.fac* file. With a more detailed description of aircraft sources, a *.fac* file can also be used to apply wind direction preferences for take offs and landings.

Details on how to set up a *.fac* file are provided in Section 7.3 of this User Guide.

.hfc file

Detailed annual hourly emissions profiles can be applied to aircraft, road and industrial source emissions using an *.hfc* file.

Details on how to set up an *.hfc* file are provided in Section 7.4 of this User Guide.

5.3 Using source oriented grids with Air File sources

As concentration gradients across linear sources such as roads and runways are significant, ADMS-Airport includes an 'Intelligent gridding' option. When activated, this model feature adds additional receptor points within the study area in order to help resolve particular features of the pollutant concentration distribution such as concentration gradients. **Figure 5.4** shows how the **Source-oriented grids** gridding option for **Road, Line, Aircraft** sources can be selected in the **Grids** screen of the ADMS-Airport interface.

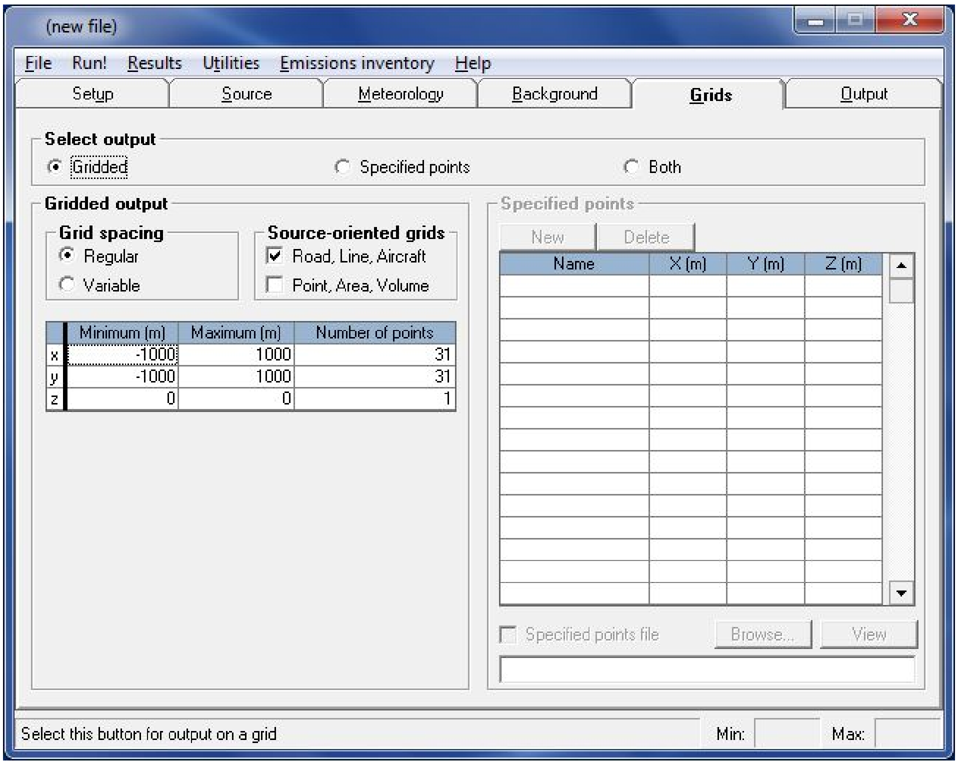


Figure 5.4 – **Grids** screen with **Source oriented grids** for **Road, Line, Aircraft** gridding option activated

ADMS-Airport adds the additional receptor points to the standard regular grid in two stages:

- A number of points can be added in and around aircraft, road and line sources. The maximum number of points available for this procedure is summarised in **Table 5.3** below, for each source type. The user can alter the maximum number of points available by use of an *.igp* file (details are given below). A reduction in the number of points may be required, for example, if model run times are restrictive, and it may be that the number of source-oriented gridding points can be reduced without visibly reducing the resolution of contour plots.

  Further details, such as the way in which the along-source intelligent gridding points are spaced, are given in Section 8.2 of this User Guide.

Source type	Default maximum number of additional receptor points	Number of points added across source	Distances at which receptors placed, relative to the centre of the source, where W is the source width*
Aircraft	2000	8	± 0.2 W, ± 0.45 W, ± W, ± 2 W
Road	5000	4	± 0.45 W, ± 2 W
Line	1000	4	± 0.45 W, ± 2 W

Table 5.3 – Summary of additional calculated source-oriented gridding receptor points for different source types (*For Air File sources, the width, W, is defined as the engine to engine width, calculated from data given in the *.air* file)

- At the end of the model run, ADMS-Airport will add further points in between the first set of source-oriented gridding points. Three sets of points are added in between each pair of sets of points added during the first stage. Concentrations at these new points along aircraft sources are calculated by linearly interpolating between the values at the first set of points. By default, this second stage of source-oriented gridding will always be carried out unless buildings are modelled, but it can be disabled via the *.igp* file, as described below.

An example *.igp* file showing default values is shown in **Figure 5.5** below. Here, the parameters LimitPointsRoads, LimitPointsLines and LimitPointsAircraft define the maximum number of additional calculated receptor points that the model can add to the output grid for a particular run, for road, line and **Air File** sources respectively.

```
&INTELLI_PARAMS
LimitPointsRoads    = 5000
LimitPointsLines    = 1000
LimitPointsAircraft = 2000
PercentageSpacing   = 0.5
ActualSpacing       = 0.0
InterpolatePoints   = 1
SpecifyRoadSrcs     = 0
NumberRoadSrcsForIGP = 0
SpecifyAircraftSrcs = 0
NumberAircraftSrcForIGP = 0
/
```

Figure 5.5 – Default settings in *.igp* file

The remaining parameters are as follows:

- The PercentageSpacing parameter allows users to control the minimum along-source spacing between the additional output points as a percentage of the size of the output domain; applies to road, line and **Air File** sources.
- The ActualSpacing parameter allows users to control the minimum along-source spacing between the additional output points as an actual distance measured in metres; applies to road, line and **Air File** sources.

- The InterpolatePoints parameter allows the user to specify whether or not the additional interpolated source-oriented gridding points are required as output; applies to road, line and **Air File** sources.
- The SpecifyRoadSrcs parameter allows the user to specify particular road sources for source-oriented gridding.
- The NumberRoadSrcsForIGP parameter specifies the number of road sources to which source-oriented gridding should be applied (only used if SpecifyRoadSrcs is 1)
- The SpecifyAircraftSrcs parameter allows the user to specify particular **Air File** sources for source-oriented gridding.
- The NumberAircraftSrcsForIGP parameter specifies the number of **Air File** sources to which source-oriented gridding should be applied (only used if SpecifyAircraftSrcs is 1)

Further details are given in **Table 5.4**, including ranges and model default values.

Parameter name	Description	Range of values	Default value
PercentageSpacing	Percentage of grid length scale that will be the minimum spacing	0.1-5.0	0.5
ActualSpacing	If this value is non-zero and is greater than the minimum allowed spacing, this value (in m) gives the actual spacing between sets of source-oriented gridding output points along each road segment	0.0-1000.0	0.0
InterpolatePoints	If this value is 1, interpolation will be used to produce additional output between the source-oriented grid points. If this value is 0, the interpolation will be disabled.	0,1	1
SpecifyRoadSrcs	If this value is 1, a list of road sources to which source-oriented gridding points should be applied should be included; if this value is 0 all road sources will be considered for source-oriented grid points.	0,1	0
NumberOfRoadSrcsForIGP	If SpecifyRoadSrcs is 1 then this specifies the number of road sources to consider for source-oriented grid points	0-3000	0
SpecifyAircraftSrcs	If this value is 1, a list of **Air File** sources to which source-oriented gridding points should be applied should be included; if this value is 0 all **Air File** sources will be considered for source-oriented grid points.	0,1	0
NumberOfAircraftSrcsForIGP	If SpecifyAircraftSrcs is 1 then this specifies the number of road sources to consider for source-oriented grid points	0-500	0

Table 5.4 – Summary of non-limit parameters in the *.igp* file

If both SpecifyRoadSrcs and SpecifyAircraftSrcs are 1 then the road sources should be listed first, followed by the ***Air File*** *sources.*

The model assumes default values if no *.igp* file is specified (further details on using an *.igp* file are given in Section 3.5.2 of the ADMS-Urban User Guide). The *.log* file reports whether an *.igp* file has been used in a model run. An example *.igp* file is supplied in the *Data* directory of the ADMS-Airport installation directory.

SECTION 6 Worked Examples and Case Study

It is recommended that the worked examples in the ADMS-Urban User Guide are undertaken before attempting these worked examples. The examples are presented in order of simplicity for a new user. The more complex examples illustrate the recommended way of modelling airport sources, if sufficient data are supplied.

All the worked examples given use ADMS-Airport Version 3.4, EMIT Version 3.2.2, the ADMS Mapper and ArcGIS.

Example 7: Modelling an Aircraft Source

In this example you will model aircraft departure sources, first as industrial volume sources and then as **Air File** sources. In particular you will learn:

- how to launch ADMS-Airport in stand-alone mode;
- how to add a volume source;
- how to enter volume source data for an aircraft;
- how to create an **Air File;**
- how to import an **Air File** into ADMS-Airport;
- how to plot aircraft sources in ArcGIS; and
- how to plot contour maps in ArcGIS.

Step 1.1 *Start ADMS-Airport and define basic setup data*

1. Start ADMS-Airport by double-clicking on the  icon.
2. Enter the name of the site and the project.

Step 1.2 *Enter source data*

1. Move to the **Source** screen by clicking on the Source tab at the top of the ADMS-Airport window. Select the **Show industrial sources** option to display the industrial source table.
2. Click on the **New** button to add a source to the table.
3. Click on the data input section of the source table. Name the source A320 TakeoffRoll and change the source type to a volume source. Change the source height to 1.75 m. This defines the height of the vertical mid-point of the volume source. Change **L1** to 3.5 m. This defines the vertical length of the volume source. Keep the source temperature as its default value.

4. Click on the **Geometry…** button. Click **New** four times to add four new vertices for the source, enter the coordinates (0,-50), (1500,-50), (1500,50) and (0,50). Click the **OK** button and return to the **Source** screen.
5. Add two further volume sources named A320 InitialClimb and A320 ClimbOut with details as given in **Table 6.1**.

Source Name	Height (m)	L1 (m)	Geometry							
			X1	Y1	X2	Y2	X3	Y3	X4	Y4
A320 TakeoffRoll	1.75	3.5	0	-50	1500	-50	1500	50	0	50
A320 InitialClimb	225	450	1500	-50	6500	-50	6500	50	1500	50
A320 ClimbOut	675	450	6500	-120	10000	-120	10000	120	6500	120

Table 6.1 – Example 7 volume source details.

Step 1.3 ***Define source emissions***

1. Click on the A320 TakeoffRoll source in the source table.
2. Click on the **Emissions…** button to enter pollutant emissions for the source.
3. NO_x is already selected as default, enter an emission rate of 1.11048 e-10 g/m^3/s. Click the **OK** button and return to the **Source** screen.
4. Enter the emissions for sources A320 InitialClimb and A320 ClimbOut as given in **Table 6.2**.

Source Name	NO_x Emission (g/m^3/s)
A320 TakeoffRoll	1.11048 e-10
A320 InitialClimb	2.29778 e-13
A320 ClimbOut	4.73000 e-13

Table 6.2 – Example 7 volume source details.

Step 1.4 ***Enter meteorological data from a file***

1. Move to the **Meteorology** screen by clicking on the tab at the top of the ADMS-Airport window.
2. In the **Site Data** section, leave the latitude as 52º. Enter a value of 0.3 for the surface roughness at the dispersion site (a suggested roughness length for an airport is in the region of 0.2-0.4 m). Make sure that the **Use advanced options** box is ticked, then click on the **Data** button and enter a Minimum Monin-Obukhov length of 20 m (a value suitable for an airport).
3. In the **Met. Data** section, select the **From file** option. Click on the **Browse** button, and select the file neutral.met from the supplied *\Data* directory, located in the ADMS-Airport install directory. This file

contains one line of meteorological data. You must therefore clear the **Met. data are hourly sequential** option.

Step 1.5 ***Enter a background concentration***

1. In this example we will not model background concentrations.

   Move to the **Background** screen by clicking on the tab at the top of the ADMS-Airport window.

2. Check that the **None** option is selected.

Step 1.6 ***Define output grids***

1. Move to the **Grids** screen by clicking on the tab at the top of the ADMS-Airport window.
2. If it is not already selected, choose **Gridded** output with **Regular** spacing.
3. Enter the x Minimum (m), Maximum (m) and Number of points as –400, 5000 and 80 respectively. Enter the y Minimum (m), Maximum (m) and Number of points as –400, 400 and 15 respectively. Enter the z Minimum (m), Maximum (m) and Number of points as 0, 0 and 1 respectively.
4. In this example, you may clear the **Source-oriented grids** options.

Step 1.7 ***Specify output parameters***

1. Move to the **Output** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Click on the **New** button and choose NO_x as the pollutant from the drop-down list.
3. Select a long term average (by selecting 'LT' in the **Short/Long** column), with an averaging time of 1 hour, and units of $\mu g/m^3$. Check that there is a tick in the **Include** column for NO_x, so that the NO_x concentrations will be calculated for this model run.
4. At the bottom of the screen, ensure that **Groups** output is selected, to calculate output for a group of sources, and make sure that the **All sources** box is ticked.

Step 1.8 ***Run ADMS-Airport***

1. From the **File** menu choose **Save As…**, enter a new file name, e.g. *example7a.upl*, and browse to the directory where you would like to save the file. It is *not* recommended that files are saved in the model installation directory. Click **OK** to save the file.
2. Run the model by choosing **Run!** from the menu bar.

Step 1.9 ***Using ADMS Mapper to view volume sources***

1. From the **Utilities** menu select **ADMS Mapper** to launch the ADMS Mapper. The Mapper window displays the **Volume sources** and **Output grid extent** layers from the file that is open in ADMS-Airport. If these layers are not displayed, click on the **Refresh Layers** button, , to refresh the view.

Step 1.10 ***Viewing contour output in ADMS Mapper***

1. When the calculation has been completed from Step 1.8, return to the ADMS Mapper by clicking on the ADMS Mapper title bar.
2. Click on the **Contour** button, .
3. Select **Long term** in the top left of the window and the *example7a.glt* output file from the list at the left of the **Contour Plotting** screen.
4. In the **Dataset to plot** box, choose NO_x concentration from the source group <All sources>.
5. Click on **Advanced Options...** to bring up the **Advanced Contour Options** screen.
6. Check the **Specify number of grid lines** option and specify 400 for each direction. Click on **Close** to return to the ADMS Contour Plotter.
7. Click on the **Plot** button and **Save Surfer Grid File As…** screen is displayed. Browse to an appropriate location (it is best to save the file with your other ADMS-Airport input/output files) and click **Save.**
8. The contours of pollutant concentration will now be displayed in the ADMS Mapper. The contour plot is currently obscuring the volume sources. Drag and drop the contour layer below the volume source layer in the legend on the left of the ADMS Mapper window.
9. You can edit the colour scheme and transparency of the contour plot, please refer to the *ADMS Mapper User Guide* for more details.
10. From the **File** menu you can export an individual layer with **Export Layer ...** or from the **Edit** menu, **Copy Map to Clipboard** copies all visible layers.

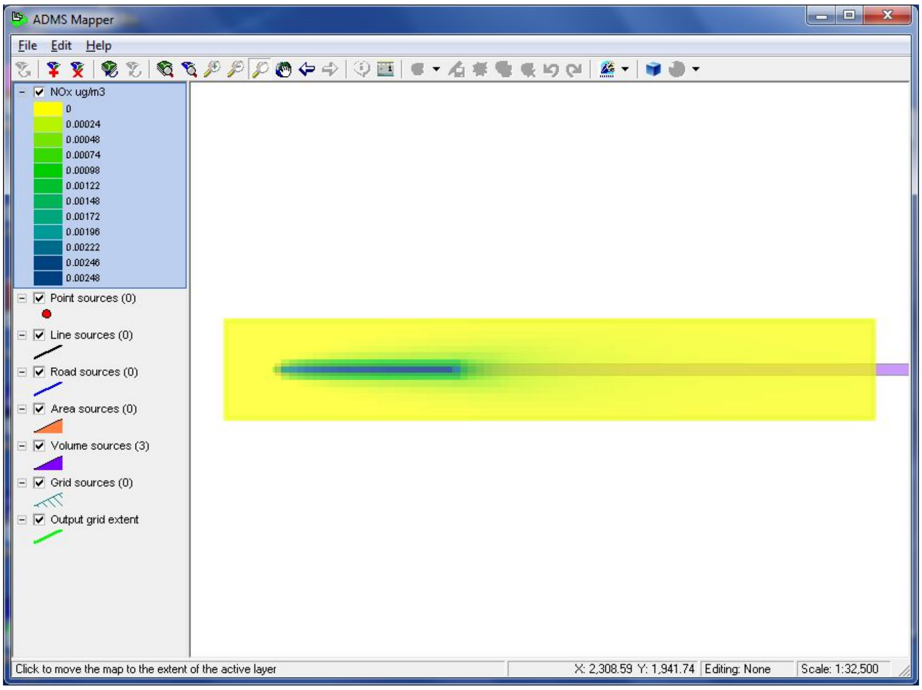


Figure 6.1 – Example 7: NO_x contours for modelling an aircraft departure with volume sources.

Step 1.11 ***Save ADMS-Airport project as a new name***

1. In the next part of the example you will use Air File sources instead of volume sources to describe the departure of the same aircraft. From the **File** menu choose **Save As…**, enter a new file name, e.g. *example7b.upl*, and browse to the directory where you would like to save the file. It is *not* recommended files are saved in the model installation directory. Click **OK** to save the file.

Step 1.12 ***Remove industrial sources from project***

1. Move to the **Source** screen by clicking on the Source tab at the top of the ADMS-Airport window. Select the **Show industrial sources** option to display the industrial source table.
2. Click on the **Delete All** button to remove all industrial sources from the project. A **Delete sources by type** menu will open, indicating the number of sources of each type. The **Volume** type should be ticked. Click **OK** to delete all volume sources.

Step 1.13 ***Creating an AIR file***

1. Open *example.air*, from the *\Data* directory, in **Microsoft Excel**.
2. To transform the data into the correct format for editing, highlight column A. Select **Text to Columns…** from the **Data** menu. Check **delimited**, click **Next >**. Check **comma**, click **Next >**. Click **Finish**.

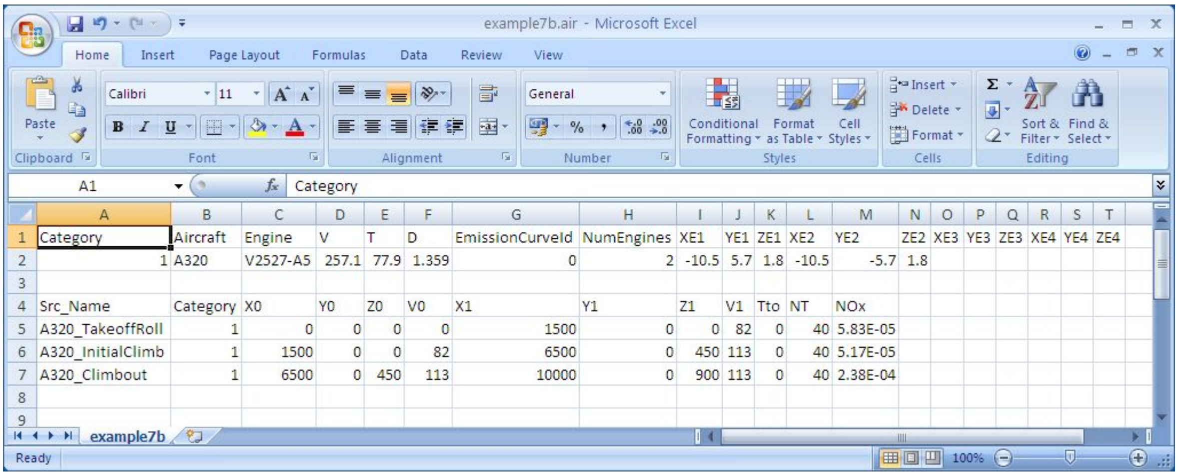
3. Amend *example.air* to contain aircraft engine parameters for a single category as given in **Table 6.3**. This information describes the buoyancy of the exhaust plume.
4. In **Excel** enter three **Air File** sources, as given in **Table 6.4**.
5. Once entered the information should look as in **Figure 6.2**.
6. From the **File** menu choose **Save As…**, select **CSV (Comma delimited) (*.csv)** from the **Save as type** drop down menu enter a new file name, e.g. *example7b.csv*, and browse to the directory where you would like to save the file.
7. Open **Windows Explorer** and navigate to the directory where your file is saved. Change the file extension from *.csv to *.air in **Windows Explorer**.
8. Open the file in **Notepad**. Remove any trailing commas from the bottom of the **Air File** such that the file looks as shown in **Figure 6.3**.

Top of AIR FILE Header	**AIR FILE Category 1**
Category	1
Aircraft	A320
Engine	V2527-A5
V	257.1
T	77.9
D	1.359
EmissionCurveId	0
NumEngines	2
XE1	-10.5
YE1	5.7
ZE1	1.8
XE2	-10.5
YE2	-5.7
ZE2	1.8
XE3	
YE3	
ZE3	
XE4	
YE4	
ZE4	

Table 6.3 – Example 7 top of AIR file category details.

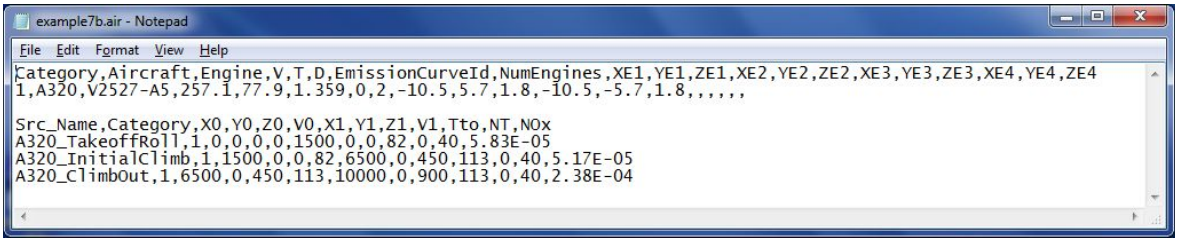
Bottom of AIR FILE Header	AIR FILE Source 1	AIR FILE Source 2	AIR FILE Source 3
Src_Name	A320_TakeoffRoll	A320_InitialClimb	A320_ClimbOut
Category	1	1	1
X0	0	1500	6500
Y0	0	0	0
Z0	0	0	450
V0	0	82	113
X1	1500	6500	10000
Y1	0	0	0
Z1	0	450	900
V1	82	113	113
Tto	0	0	0
NT	40	40	40
NOx	5.83E-05	5.17E-05	2.38e-04

Table 6.4 – Example 7 bottom of AIR file source details.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Category	Aircraft	Engine	V	T	D	EmissionCurveId	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
2	1	A320	V2527-A5	257.1	77.9	1.359	0	2	-10.5	5.7	1.8	-10.5	-5.7	1.8						
3																				
4	Src_Name	Category	X0	Y0	Z0	V0	X1	Y1	Z1	V1	Tto	NT	NOx							
5	A320_TakeoffRoll	1	0	0	0	0	1500	0	0	82	0	40	5.83E-05							
6	A320_InitialClimb	1	1500	0	0	82	6500	0	450	113	0	40	5.17E-05							
7	A320_Climbout	1	6500	0	450	113	10000	0	900	113	0	40	2.38E-04							

Figure 6.2 – Example 7 AIR file inputs




```
Category,Aircraft,Engine,V,T,D,EmissionCurveId,NumEngines,XE1,YE1,ZE1,XE2,YE2,ZE2,XE3,YE3,ZE3,XE4,YE4,ZE4
1,A320,V2527-A5,257.1,77.9,1.359,0,2,-10.5,5.7,1.8,-10.5,-5.7,1.8,,,,,,

Src_Name,Category,X0,Y0,Z0,V0,X1,Y1,Z1,V1,Tto,NT,NOx
A320_TakeoffRoll,1,0,0,0,0,1500,0,0,82,0,40,5.83E-05
A320_InitialClimb,1,1500,0,0,82,6500,0,450,113,0,40,5.17E-05
A320_ClimbOut,1,6500,0,450,113,10000,0,900,113,0,40,2.38E-04
```

Figure 6.3 – Example 7 AIR file

Step 1.14 ***Adding aircraft AIR FILE sources***

1. In **ADMS-Airport** move to the **Source** screen by clicking on the Source tab at the top of the ADMS-Airport window. Select the **Show Aircraft Sources** option to display the aircraft source table.
2. Check the box marked **Model aircraft sources**.

3. **Browse** to locate the **Air File** you just created, click on the file and select **Open**.
4. The sources in the **Air File** and their coordinate locations are now shown in the source window (you may have to click **Refresh** first). You can also view the **Air File** selected by clicking **View**.

Step 1.15 ***Define output grids***

1. Move to the **Grids** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Select the **Road, Line, Aircraft** option in the **Source-oriented grids** section.

Step 1.16 ***Run ADMS-Airport***

1. From the **File** menu choose **Save**. Click **OK** to save the file.
2. Run the model by choosing **Run!** from the menu bar.

Step 1.17 ***Using ADMS Mapper to view aircraft sources***

1. From the **Utilities** menu select **ADMS Mapper** to launch the ADMS Mapper. The ADMS Mapper window will display the aircraft sources in the **Airport sources** layer and the **Output grid extent** layer, from the file that is open in ADMS-Airport. If not, click on the **Refresh Layers** button, , to refresh the view.

Step 1.18 ***Viewing contour output in the ADMS Mapper***

1. In ADMS Mapper, click on the **Contour** button, .
2. Select **Long term** in the top left of the window and the *example7b.glt* output file from the list at the left of the **Contour Plotting** screen.
3. In the **Dataset to plot** box, choose NO_x concentration from the source group <All sources>.
4. Click on **Advanced Options…** to bring up the **Advanced Contour Options** screen.
5. Check the **Specify number of grid lines** option and specify 400 for each direction. Click on **Close** to return to the ADMS Contour Plotter.
6. Click on the **Plot** button and **Save Surfer Grid File As…** screen is displayed. Browse to an appropriate location (it is best to save the file with your other ADMS-Airport input/output files) and click **Save.**
7. The pollutant concentrations contour will now be displayed in the ADMS Mapper. The contour plot is currently obscuring the aircraft sources. Drag and drop the contour layer below the aircraft source layer.

8. You can edit the colour scheme and transparency of the contour plot, please refer to the *ADMS Mapper User Guide* for more details.

9. From the **File** menu you can export an individual layer with **Export Layer ...** or from the **Edit** menu, **Copy Map to Clipboard** copies all visible layers.

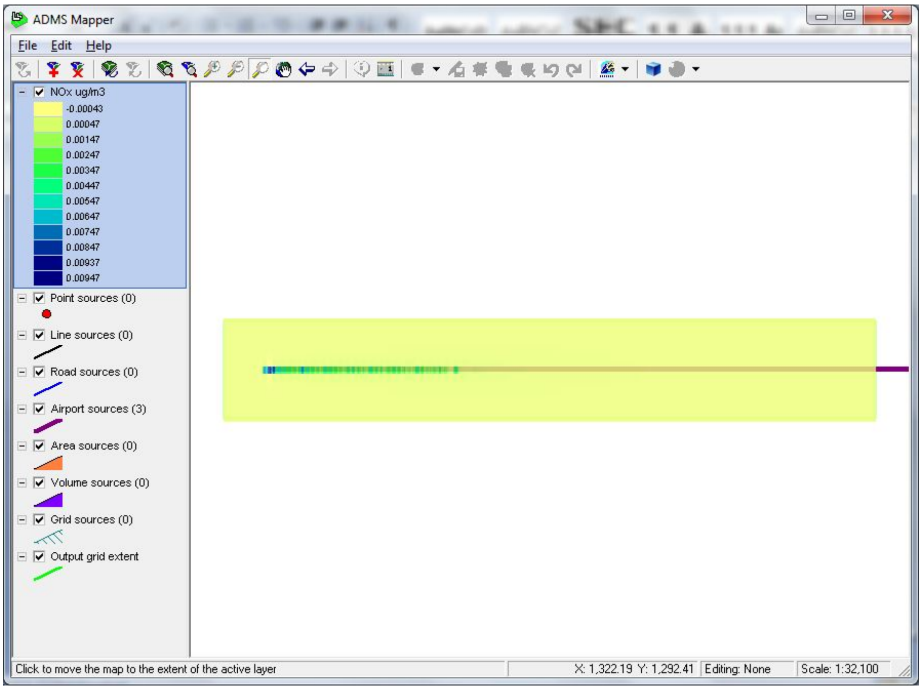


Figure 6.4 – Example 7 results of modelling an aircraft departure with aircraft sources.

Example 8: Using EMIT to Build an Emissions Inventory Database

In this example you will set up and populate a simple airport emissions inventory in EMIT. In particular you will learn:

- how to plan an EMIT emissions inventory for an airport;
- how to launch EMIT;
- how to add emission groups to EMIT;
- how to enter airport emissions sources into emission groups in EMIT;
- how to calculate emissions for the complete inventory in EMIT;
- how to convert an EMIT database into an emissions inventory for import into ADMS-Airport; and
- how to plot the sources in ArcGIS.

Step 2.1 *Planning an EMIT emissions inventory for an airport*

1. Firstly decide the types of airport sources to be considered at the airport. This example includes airport sources as described in Section 4 of this User Guide. The following emission sources will be considered:
   - Aircraft main engine emissions;
   - Aircraft APU emissions;
   - Aircraft GSE emissions;
   - Airport static source emissions; and
   - Urban emissions.
2. Next consider these source types in more detail, as shown in **Figure 6.5**. In this example the aircraft main engine emissions will be calculated according to the simple scenario described in Section 4.2.3 using EMIT emission factors. The aircraft APU, aircraft GSE, airport static source and urban emissions will be calculated using EMIT emission factors.

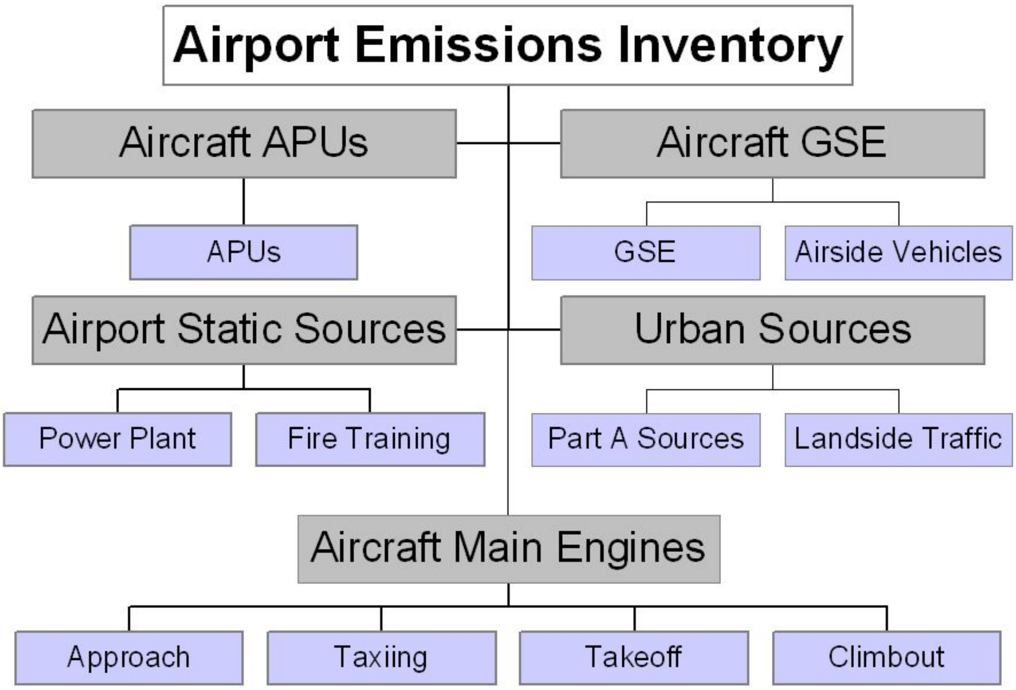
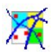


Figure 6.5 – Airport emissions inventory plan: Boxes shaded grey represent the different types of airport emissions discussed in Section 4 and boxes shaded blue represent the emissions groups to be entered into EMIT.

Step 2.2 ***Start EMIT and create a new emissions inventory***

1. Start EMIT by double-clicking on the  icon.
2. From the File menu choose **New**, enter a new file name e.g. *example8_EMIT.mdb*, and browse to the directory where you would like to save the file. Click **Save** to save the file.
3. Create a new inventory by clicking **New**.
4. Enter the name and a description of the inventory.

Step 2.3 ***Adding emission groups to an EMIT emissions inventory***

1. From the **Data** menu select **Groups**.
2. Enter a new group by clicking **New...**. Enter the group name Aircraft Approach. Select **Volume** from the **Source Type** dropdown menu. Ensure that the button **Calculate with emission factors** is selected. Select **ICAO 15 + Other** from the **Emission Factors** dropdown menu, the **Year** is set to 2007 as default. Click **OK**.
3. Add further new groups as detailed in **Table 6.5**. Once complete, click **Close**.
4. Click **Add...**, from the **Group** dropdown menu select the group named Aircraft Approach then click **Add**. A message "New inventory contents have been saved" appears, click **OK**. Repeat this for each of the groups in **Table 6.5**. Once all source groups are added click **Close**.

Group	Source Type	Emissions	EMIT factors	Greenhouse Gas Sector	Year	Fleet Components	Route Type
Aircraft Approach	VOLUME	Calculate with emissions factors	ICAO 15 + Other	-	2007	-	-
Aircraft Taxiing	VOLUME	Calculate with emissions factors	ICAO 15 + Other	-	2007	-	-
Aircraft Takeoff	VOLUME	Calculate with emissions factors	ICAO 15 + Other	-	2007	-	-
Aircraft Climb	VOLUME	Calculate with emissions factors	ICAO 15 + Other	-	2007	-	-
Aircraft APU	VOLUME	Calculate with emissions factors	APU 2004	-	2004	-	-
Aircraft GSE	VOLUME	Calculate with emissions factors	AIRPORT GSE 2007	-	2007	-	-
Airside Vehicles	-------------------------------- Not modelled --------------------------------						
Airport Power Plant	POINT	Enter emissions manually	-	Energy	2007	-	-
Airport Fire Training	VOLUME	Enter emissions manually	-	Energy	2007	-	-
Part A	POINT	Enter emissions manually	-	Energy	2007	-	-
Surrounding Roads	ROAD	Calculate with emissions factors	EURO 2009 Urban	-	2007	Heavy/Light/ Mcycle	EU 09 [3] Urban 07

Table 6.5 – Example 8 group details.

Step 2.4 ***Adding aircraft sources to an EMIT emission group manually***

1. In this example operations at a small airport are to be input, which will consist daily of three landing take-off cycles (LTOs) of an Airbus A320, six LTOs of a Boeing 737-500, six LTOs of an Embraer 145 and six LTOs of a British Aerospace 146-100.

   Select the Aircraft Approach source group and then click **Open Group**. Click **Add** to add an Aircraft Approach source.

2. Enter the **Source Name** A320 Approach.
3. Set **Depth (m)** to 450 and **Elevation (m)** to 900.
4. In the **Aircraft** tab click **Add**. From the **Aircraft, engine, (UID), num of engines** dropdown menu select Airbus A320-100 Series , V2500-A1 , (1IA001) , 2, in the **Thrust** field enter 30, in the **LTO** field enter 1095 and in the **TIM (min)** field enter 4. Click **Apply** in the lower right corner of the left hand panel.

   The number of LTO cycles is input as an annual figure.

5. In the **Emissions** tab click **Recalculate** to calculate the aircraft emissions.

6. In the **Vertices** tab check the box marked **Edit Vertices**. Enter the following vertices (-26700,3150), (-26700,3250), (32900,3250) and (32900,3150). Click **Apply** in the lower right corner of the left hand panel. Click **Close**.
7. Add further sources to the Aircraft Approach group as shown in **Table 6.6**. Enter the spatial information as shown in **Table 6.7**.
8. Return to the group overview screen by clicking **Close** in the source screen.

Source Group	Source Name	Data Item	Field Name		
		Aircraft, engine, (UID), num of engines	Thrust (%)	LTO	TIM (min)
Aircraft Approach	A320 Approach	Airbus A320-100 Series , V2500-A1 , (1IA001) , 2	30	1095	4
Aircraft Approach	737-500 Approach	Boeing 737-500 Series , CFM56-3C-1 (Rerated) , (1CM006) , 2	30	2190	4
Aircraft Approach	Emb145 Approach	Embraer ERJ145 , AE3007A1/1 , (6AL009) , 2	30	2190	4
Aircraft Approach	BAe146-100 Approach	BAE 146-100 , ALF 502R-5 , (1TL003) , 4	30	2190	4

Table 6.6 – Example 8 source details for the Aircraft Approach group.

Source Group	Source Name	Depth (m)	Elevation (m)	X1	Y1	X2	Y2	X3	Y3	X4	Y4
Aircraft Approach	A320 Approach	900	450	-26300	3150	-26300	3250	32900	3250	32900	3150
Aircraft Approach	737-500 Approach	900	450	-26300	3150	-26300	3250	32900	3250	32900	3150
Aircraft Approach	Emb145 Approach	900	450	-26300	3150	-26300	3250	32900	3250	32900	3150
Aircraft Approach	BAe146-100 Approach	900	450	-26300	3150	-26300	3250	32900	3250	32900	3150

Table 6.7 – Example 8 spatial details for the Aircraft Approach group.

The aircraft sources used in this example have the same location of emissions for all aircraft types. This is a simplification and when modelling an airport you may wish to add more detail by describing the emissions from different aircraft types with different geographical extents.

Step 2.5 *Adding aircraft sources to an EMIT emission group using the import wizard*

1. All the remaining aircraft source and spatial details, shown in **Tables 6.8** and **6.9**, can be input as described in Step 2.4. However for a large number of sources it may be preferable to use the EMIT import wizard. Import file formats are discussed in Section 6 of the EMIT User Guide.

   Return to the Database screen by clicking **Close** in the Inventory screen.

2. From the **File** menu select **Import Data**.

3. Click **Browse...** and select the *AircraftTaxiing.csv* file for import to EMIT that can be found in the *\Data\Example8* directory in your ADMS-Airport installation directory. Click **Open** and then click **Next >**.
4. Select the emissions inventory, then select the *Aircraft Taxiing* group as the destination EMIT group. Click **Next >**.
5. Ensure that all fields are selected for import. Click **Next >**.
6. You will find that each of the field names corresponds to one of the fields shown in **Table 6.8**. Select **Next >**.
7. Some optional fields are missing from the input file, select **Next >** to continue.
8. A list of the fields to be imported is shown, select **Next >** to continue.
9. Click **Next >** to carry out checks of the data before import to EMIT.
10. Click **Import Now** to import the data into EMIT.
11. Click **Exit** to exit the EMIT import wizard.
12. Repeat this process for the Aircraft Takeoff and Aircraft Climb groups with import files *AircraftTakeoff.csv* and *AircraftClimb.csv* respectively.

Source Group	Source Name	Data Item Aircraft, engine, (UID), num of engines	Field Name Thrust (%)	LTO	TIM (min)
Aircraft Taxiing	A320 Taxiing	Airbus A320-100 Series , V2500-A1 , (1IA001) , 2	7	1095	26
Aircraft Taxiing	737-500 Taxiing	Boeing 737-500 Series , CFM56-3C-1 (Rerated) , (1CM006) , 2	7	2190	26
Aircraft Taxiing	Emb145 Taxiing	Embraer ERJ145 , AE3007A1/1 , (6AL009) , 2	7	2190	26
Aircraft Taxiing	BAe146-100 Taxiing	BAE 146-100 , ALF 502R-5 , (1TL003) , 4	7	2190	26
Aircraft Takeoff	A320 Takeoff	Airbus A320-100 Series , V2500-A1 , (1IA001) , 2	100	1095	0.7
Aircraft Takeoff	737-500 Takeoff	Boeing 737-500 Series , CFM56-3C-1 (Rerated) , (1CM006) , 2	100	2190	0.7
Aircraft Takeoff	Emb145 Takeoff	Embraer ERJ145 , AE3007A1/1 , (6AL009) , 2	100	2190	0.7
Aircraft Takeoff	BAe146-100 Takeoff	BAE 146-100 , ALF 502R-5 , (1TL003) , 4	100	2190	0.7
Aircraft Climb	A320 Climb	Airbus A320-100 Series , V2500-A1 , (1IA001) , 2	85	1095	2.2
Aircraft Climb	737-500 Climb	Boeing 737-500 Series , CFM56-3C-1 (Rerated) , (1CM006) , 2	85	2190	2.2
Aircraft Climb	Emb145 Climb	Embraer ERJ145 , AE3007A1/1 , (6AL009) , 2	85	2190	2.2
Aircraft Climb	BAe146-100 Climb	BAE 146-100 , ALF 502R-5 , (1TL003) , 4	85	2190	2.2

Table 6.8 – Example 8 source details for Aircraft Taxiing, Aircraft Takeoff and Aircraft Climb groups.

Source Group	Source Name	Depth (m)	Elevation (m)	X1	Y1	X2	Y2	X3	Y3	X4	Y4
Aircraft Taxiing	A320 Taxiing	3.5	1.75	1200	3200	1200	1200	5400	1200	5400	3200
Aircraft Taxiing	737-500 Taxiing	3.5	1.75	1200	3200	1200	1200	5400	1200	5400	3200
Aircraft Taxiing	Emb145 Taxiing	3.5	1.75	1200	3200	1200	1200	5400	1200	5400	3200
Aircraft Taxiing	BAe146-100 Taxiing	3.5	1.75	1200	3200	1200	1200	5400	1200	5400	3200
Aircraft Takeoff	A320 Takeoff	3.5	1.75	-550	3175	-550	3225	7150	3225	7150	3175
Aircraft Takeoff	737-500 Takeoff	3.5	1.75	-550	3175	-550	3225	7150	3225	7150	3175
Aircraft Takeoff	Emb145 Takeoff	3.5	1.75	-550	3175	-550	3225	7150	3225	7150	3175
Aircraft Takeoff	BAe146-100 Takeoff	3.5	1.75	-550	3175	-550	3225	7150	3225	7150	3175
Aircraft Climb	A320 Climb	900	450	-4200	3120	-4200	3280	10800	3280	10800	3120
Aircraft Climb	737-500 Climb	900	450	-4200	3120	-4200	3280	10800	3280	10800	3120
Aircraft Climb	Emb145 Climb	900	450	-4200	3120	-4200	3280	10800	3280	10800	3120
Aircraft Climb	BAe146-100 Climb	900	450	-4200	3120	-4200	3280	10800	3280	10800	3120

Table 6.9 – Example 8 spatial details for Aircraft Taxiing, Aircraft Takeoff and Aircraft Climb groups.

Step 2.6 ***Adding APU sources to an EMIT emission group***

1. Input APU operations to complement the aircraft movements in Step 2.4.

   Import APU information to the Aircraft APU group by importing *AircraftAPUs.csv* using the EMIT import wizard as shown in Step 2.5. If you would prefer to input the data manually, you can do so in a similar manner to Step 2.4. The information is given in **Table 6.10**.

Source Group	Source Name	Auxiliary Power Unit	Hours Per Year	Depth (m)	Elevation (m)	X1	Y1	X2	Y2	X3	Y3	X4	Y4
Aircraft APU	A320 APU	APU GTCP 36-300 (80HP)	1368.75	12	6	3050	1200	3450	1200	3450	1950	3050	1950
Aircraft APU	737-500 APU	APU GTCP85-129 (200HP)	1642.5	12	6	3050	1200	3450	1200	3450	1950	3050	1950
Aircraft APU	Emb145 APU	APU GTCP 36-150[]	1095	12	6	3050	1200	3450	1200	3450	1950	3050	1950
Aircraft APU	BAe146-100 APU	APU GTCP 36-100	1095	12	6	3050	1200	3450	1200	3450	1950	3050	1950

Table 6.10 – Example 8 source and spatial details for APU group.

Step 2.7 ***Adding GSE sources to an EMIT emission group***

1. Input GSE operations to complement the aircraft movements in Step 2.4.

   Import GSE information to the Aircraft GSE group by importing *AircraftGSE.csv* using the EMIT import wizard as shown in Step 2.5. If you would prefer to input the data manually the information is given in **Tables 6.11** and **6.12**. Input information in a similar manner to Step 2.4.

Source Group	Source Name	GSE, Power, Load Factor (Fuel Type)	Hours per Year
Aircraft GSE	All GSE	400 Hz ground power unit , 105-149 kW , 50% , (Diesel)	4051.50
Aircraft GSE	All GSE	Air climate unit , 150 kW , 50% , (Diesel)	182.50
Aircraft GSE	All GSE	Baggage belt loader , 33 kW , 25% , (Diesel)	2847.00
Aircraft GSE	All GSE	Baggage cart tractor , , , (Electric)	3723.00
Aircraft GSE	All GSE	Cabin cleaning truck , 132 kW , 10-60% , (Diesel)	346.75
Aircraft GSE	All GSE	Cabin cleaning van , 61 kW , 10-75% , (Diesel)	930.75
Aircraft GSE	All GSE	Cargo delivery , 33 kW , 25% , (Diesel)	1277.50
Aircraft GSE	All GSE	Cargo loader , 62 kW , 25% , (Diesel)	985.50
Aircraft GSE	All GSE	Cargo loader main deck , 59 kW , 25% , (Diesel)	456.25
Aircraft GSE	All GSE	Catering truck , 85-130 kW , 10-25% , (Diesel)	511.00
Aircraft GSE	All GSE	Fork lift , 66 kW , 25% , (Diesel)	219.00
Aircraft GSE	All GSE	Generator for vacuum cleaner - TYPE 1 , 2.2 kW , 80% , (Gasoline)	182.50
Aircraft GSE	All GSE	Generator for vacuum cleaner - TYPE 2 , 3.5 kW , 80% , (Gasoline)	547.50
Aircraft GSE	All GSE	Large fork lift , 30-120 kW , 25% , (Diesel)	219.00
Aircraft GSE	All GSE	Lavatory truck , 117 kW , 25% , (Diesel)	730.00
Aircraft GSE	All GSE	Line maintenance truck , 70-120 kW , 25% , (Diesel)	766.50
Aircraft GSE	All GSE	Passenger stairs , 30-65 kW , 25% , (Diesel)	1204.50
Aircraft GSE	All GSE	Refuelling tanker truck , 200 kW , 10% , (Diesel)	2920.00
Aircraft GSE	All GSE	Water truck , 117 kW , 25% , (Diesel)	730.00

Table 6.11 – Example 8 source details for Aircraft GSE group.

Source Group	Source Name	Depth (m)	Elevation (m)	X1	Y1	X2	Y2	X3	Y3	X4	Y4
Aircraft GSE	All GSE	2	1	3050	1200	3450	1200	3450	1950	3050	1950

Table 6.12 – Example 8 vertex details for Aircraft GSE group.

Step 2.8 ***Adding power plant and part A sources to EMIT emission groups***

1. Input power plant and part A source emissions as described in **Table 6.13**.

   Select the Airport Power Plant source group and then click **Open Group**. Click **Add** to add a source.

2. Enter the **Source Name** Power Plant.
3. Enter a **Stack Height (m)** of 25 m, **Stack Diameter (m)** of 1.8, **Exit Velocity (m/s)** of 10 and **Exit Temperature (ºC)** of 130.
4. Select the **Emissions** tab on the right hand side of the window. Click **Add** and select **NOx** from the dropdown menu. Enter 2.2 in the **Emission rate (tonnes/yr)** box. Click **Apply** in the left hand window.
5. In the **Vertices** tab check the box marked **Edit Vertices**. Enter the following coordinates (1200,1200). Click **Apply** in the lower right corner of the left hand panel. Click **Close**.
6. Click **Close** to exit the Airport Power Plant source group.

7. Repeat this process for the Part A Sources group with the information given in **Table 6.13**.

Source Group	Source Name	Stack Height	Stack Diameter	Exit Velocity	Exit Temperature	Emissions (tonnes per year) NO_x	Vertices	
		(m)	(m)	(m/s)	(°C)		X1	Y1
Airport Power Plant	Power Plant	25	1.8	10	130	2.2	1200	1200
Part A Sources	Part A	20	2	15	150	50	4200	200

Table 6.13 – Example 8 source and vertex details for Airport Power Plant and Part A Sources groups.

Step 2.9 ***Adding fire training sources to EMIT emission groups***

1. Input fire training emissions as described in **Table 6.14**.

   Select the Airport Fire Training source group and then click **Open Group**. Click **Add** to add a source.

2. Enter the **Source Name** Fire Training.
3. Set the **Depth (m)** to 10 m and the **Elevation (m)** to 5 m.
4. Select the **Emissions** tab in the right hand side of the window. Click **Add** and select **NOx** from the dropdown menu. Enter 0.002 in the **Emission rate (tonnes/yr)** box. Click **Apply** in the left hand window.
5. In the **Vertices** tab check the box marked **Edit Vertices**. Enter the following vertices (6675,1125), (6725,1125), (6725,1175) and (6675,1175). Click **Apply** in the lower right corner of the left hand panel. Click **Apply**, a message appears asking if you want to maintain the g/m^3/s value or the tonnes per year value, select **Keep tonnes/year**.
6. Then click **Close** to exit the source screen.
7. Click **Close** to exit the Airport Fire Training source group.

Source Group	Source Name	NO_x Emissions	Depth	Elevation	Vertices							
		(tonnes per year)	(m)	(m)	X1	Y1	X2	Y2	X3	Y3	X4	Y4
Airport Fire Training	Fire Training	0.002	10	5	6675	1125	6725	1125	6725	1175	6675	1175

Table 6.14 – Example 8 source details for the Airport Fire Training group.

Step 2.10 ***Adding surrounding roads sources to an EMIT emission group***

1. Input surrounding road emissions as described in **Table 6.15**.

   Select the Surrounding Roads source group and then click **Open Group**. Click **Add** to add a source.

2. Enter the **Source Name** Road A.
3. Select a speed of 50 from the **Speed (km/hr)** dropdown menu.
4. In the **Spatial** tab, enter a **Road Width (m)** of 20.

5. Select the **Vertices** tab in the right hand side of the window. Check the box **Edit Vertices**. Click **Add** twice. Enter the following vertices (21,525), (2975,1025), (3475,1025) and (6275,1025).
6. Select the **Traffic** tab. Enter 30 in the **Motorcycles** box, 1900 in the **Light vehicles** box and 70 in the **Heavy vehicles** box.
7. Select **Apply** from the left hand window.
8. Select the **Emissions** tab and click **Recalculate**.
9. Click **Close** to exit the source.
10. Repeat this process for the Road B source given in **Table 6.15**.

Source Group	Source Name	Road Width (m)	Speed (km/hr)	Vertices								Traffic		
				X1	Y1	X2	Y2	X3	Y3	X4	Y4	Motorcycles	Light Vehicles	Heavy Vehicles
Surrounding Roads	Road A	20	50	21	525	2975	1025	3475	1025	6275	1025	30	1900	70
Surrounding Roads	Road B	10	30	2975	1025	2975	1150	3475	1150	3475	1025	15	1220	45

Table 6.15 – Example 8 source details for the Surrounding Roads group.

11. Click **Close** to exit the Surrounding Roads source group.

Step 2.11 *Calculating emissions for the complete EMIT emissions inventory*

1. Set up the geographical extents of the EMIT emissions inventory by clicking **Inventory Properties…** in the source group overview window.
2. Leave the **Cell Size** set as 1000. In the boxes **South West** set **X** to -30000 and **Y** to -1000. In the boxes **North East** set **X** to 33000 and **Y** to 5000.
3. Check the **Specific time period** button. Set the **Start Date** to 06 Sep 2007 and the **Start Time** to 00:00. Set the **Stop Date** to 07 Sep 2007 and the **Stop Time** to 00:00. Click **OK**.

This is set as we are only interested in 1 day of emissions. Usually we are concerned with a year of emissions in which case the Annual average emissions button would be checked.

4. Click **Calculate** to calculate total emissions for all source groups in the inventory over the selected extents.
5. Click **View Totals**, the total emissions should be as given in Table 6.16.
6. Click **Close** to exit the total emissions screen.

Group	BENZENE	BUTADIENE	CO	NO2	NOx	PM10	PM2.5	SO2	VOC	CO2
Aircraft Approach	-	-	8.36E-03	2.85E-03	1.90E-02	1.08E-04	1.08E-04	2.19E-03	3.23E-04	-
Aircraft APU	-	-	1.69E-02	8.07E-04	8.07E-03	-	-	-	7.88E-04	-
Aircraft Climb	-	-	1.80E-03	3.14E-03	5.93E-02	1.52E-04	1.52E-04	3.33E-03	1.88E-04	-
Aircraft GSE	-	-	5.23E-03	4.51E-04	9.03E-03	6.98E-04	6.98E-04	0	1.30E-03	-
Aircraft Takeoff	-	-	6.58E-04	1.21E-03	2.68E-02	5.82E-05	5.82E-05	1.27E-03	7.17E-05	-
Aircraft Taxiing	-	-	1.79E-01	8.73E-03	2.33E-02	3.36E-04	3.36E-04	5.63E-03	1.88E-02	-
Airport Fire Training	-	-	-	2.74E-07	5.48E-06	-	-	-	-	-
Airport Power Plant	-	-	-	3.01E-04	6.03E-03	-	-	-	-	-
Part A	-	-	-	6.85E-03	1.37E-01	-	-	-	-	-
Surrounding Roads	7.12E-05	5.81E-05	2.26E-02	1.06E-03	6.45E-03	2.33E-04	2.11E-04	7.55E-05	2.67E-03	2.45E+00
TOTAL	**7.12E-05**	**5.81E-05**	**2.35E-01**	**2.54E-02**	**2.95E-01**	**1.58E-03**	**1.56E-03**	**1.25E-02**	**2.42E-02**	**2.45E+00**

Group	METHANE	N2O	NH3	B[a]P
Surrounding Roads	1.89E-04	1.36E-04	6.69E-04	4.76E-08
TOTAL	**1.89E-04**	**1.36E-04**	**6.69E-04**	**4.76E-08**

Table 6.16 – Example 8 total emissions (in tonnes).

Step 2.12 ***Export an EMIT emissions inventory for import into ADMS-Airport and viewing in ArcGIS***

1. In **EMIT** from the source groups overview screen select the Aircraft Approach group. Click **Export Group…**, select **To Inventory…** from the dropdown list. Click **New** and name the new inventory *Example8_Inventory.mdb*. Save the inventory to a suitable working location. Ensure that the **All Pollutants** button is checked and click **Export**.
2. Export the remaining source groups to this inventory: Selecting each group in turn, click **Export Group…**, select **To Inventory…** from the dropdown list. If not already selected, click **Browse** to find the file *Example8_Inventory.mdb* just created. Ensure that the **All Pollutants** button is checked and click **Export**.
3. Select **Export Totals**. Browse to *Example8_Inventory.mdb*, set the **Grid Depth** to 10m, and click **Export**. This exports aggregated grids of the emissions from all EMIT sources to the ADMS emissions inventory database.

   It is not recommended to represent aircraft volume sources as aggregated emissions in ADMS-Airport, since the depth of the sources vary markedly and representing all the aircraft emissions near to the ground would be unrepresentative. Thus the aircraft sources must be represented in ADMS-Airport as explicit sources.

4. The file *Example8_Inventory.mdb* contains the emissions inventory compatible for import into ADMS-Airport. Click **Close** and then from the toolbar select **File** and then **Exit** to exit EMIT.

Step 2.13 ***Viewing an emissions inventory in ArcGIS***

1. Open **ArcGIS** and select to start with a New empty map. From the **View** menu choose **Data View**. Also ensure that the Emissions Inventory toolbar is active; from the **View** menu select **Toolbars** and ensure that **Emissions Inventory** is checked.

2. From the Emissions Inventory toolbar select the  icon to **Choose emissions inventory**. Navigate to the location of the file *Example8_Inventory.mdb* and click on the file to highlight it and then select **Open**. The sources entered into EMIT will now be visible in ArcGIS.

3. Select the EI Grid Source layer, right click and select **Properties….** Select the **Symbology** tab and select **Quantities**, **Graduated colors** from the left hand window. In the **Field** grouping select the **Value** as **NOx_g/m2/s** from the dropdown menu. Click **OK**.

   Plots of the distribution of emissions are shown in **Figures 6.6** and **6.7**.

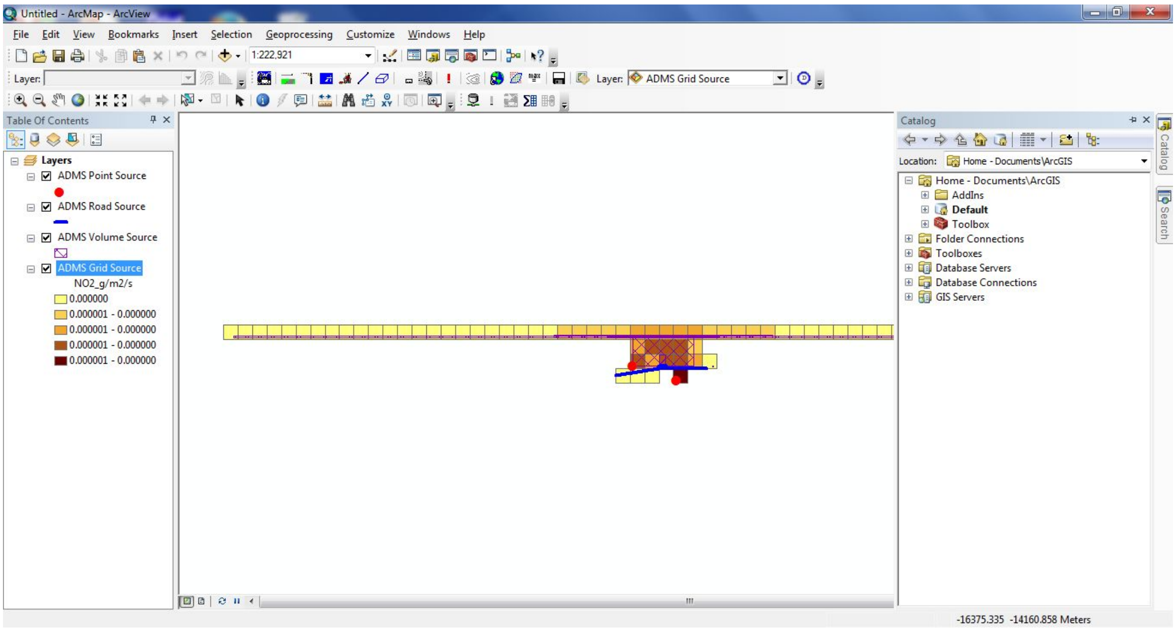


Figure 6.6 – Example 8 fictional airport sources and gridded emissions.

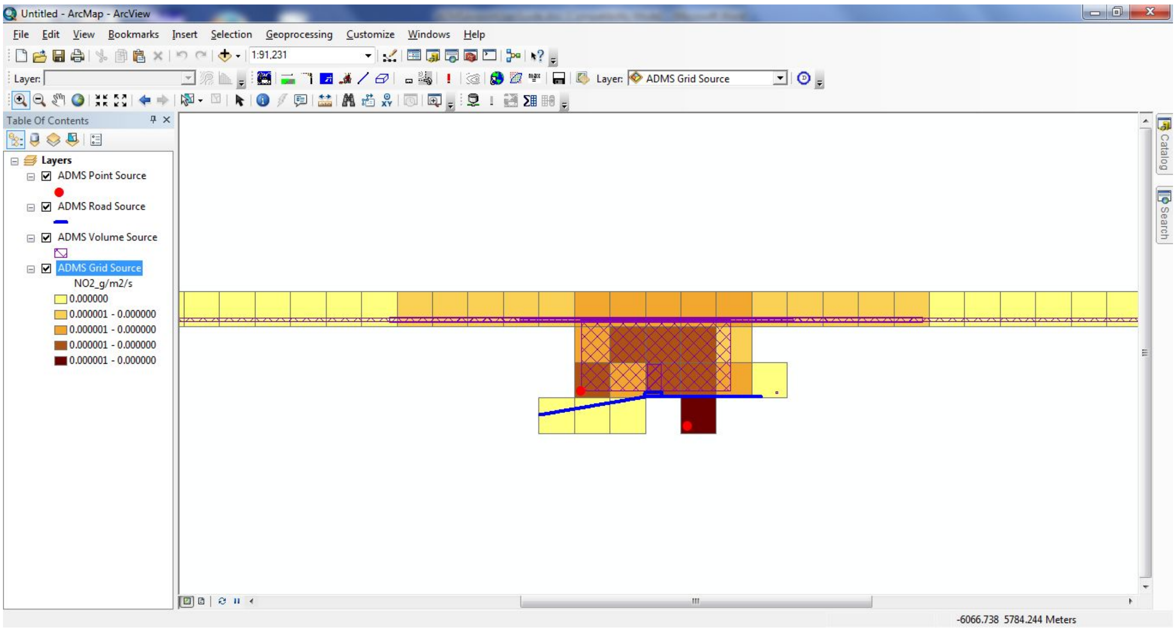


Figure 6.7 – Example 8 fictional airport sources and gridded emissions – detail.

Air file sources are not entered into EMIT, as such the emissions specified in the ***Air File*** *are not aggregated into the emission totals and aren't disaggregated in the model.*

Example 9: Modelling a Simple Airport

In this example you will model a simple airport from the emissions database developed in example 8. In particular you will learn:

- how to add source data from an emissions inventory;
- how to plot results in ArcGIS; and
- how to enhance concentration results around aircraft volume sources.

Step 3.1 *Start ADMS-Airport and define basic setup data*

1. Start ADMS-Airport by double-clicking on the  icon.
2. Enter the name of the site and the project.

Step 3.2 *Import source data from an emissions inventory*

1. From the toolbar select **File, Preferences, Inventory Database…**.
2. Select **Browse** to locate the inventory database from example 8, click **Open**, and then click **OK**.
3. Move to the **Source** screen by clicking on the tab at the top of the ADMS-Airport window.
4. Select **Show Road Sources**. Check that the **Current dataset** defined for the road traffic emissions is **UK EFT v5.1 (2 VC).** If not, click **Change** and select this dataset from the list.

   Although the road traffic emissions are imported directly from the emissions inventory and are not recalculated, the **Current dataset** *in the interface must match that in the emissions inventory. EMIT 3.2.2 saves the road source dataset by default as* **UK EFT v5.1 (2 VC)**.

5. From the toolbar select **Emissions Inventory**, **Import from Emissions Inventory**.
6. No pollutants are to be imported from the emissions inventory, click **Next >**.
7. Import all sources from the emissions inventory, by selecting **Add All**, then click **Finish**. The warning message is shown as in **Figure 6.8**, click **OK** to continue.

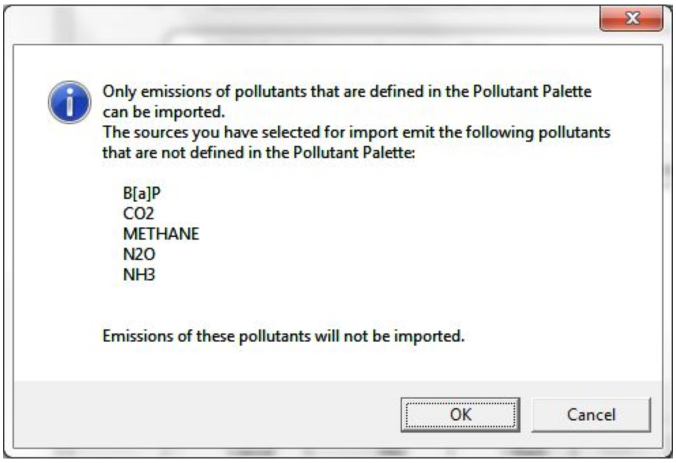


Figure 6.8 – Example 9 warning message when importing sources from an emissions inventory.

Step 3.3 ***Enter meteorological data from a file***

1. Move to the **Meteorology** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Set the Surface roughness to 0.3 m and the latitude to 52º. Make sure that the **Use advanced options** box is ticked, then click the **Data** button and set the Minimum Monin-Obukhov length to 20 m.
3. Select the **From file** option further down the screen. Click on the **Browse** button, and select the file *oneday.met* from the supplied *\Data* directory. This file contains 24 lines of hourly sequential meteorological data.
4. Make sure that the **Met. Data are hourly sequential** box is ticked.

Step 3.4 ***Enter a background concentration***

1. Move to the **Background** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Check that the **None** option is selected.

Step 3.5 ***Define output grids***

1. Move to the **Grids** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Select **Gridded** output with **Regular** spacing. Select the **Road, Line, Aircraft** option in the **Source-oriented grids** section.
3. Enter the **x Minimum (m)**, **Maximum (m)** and **Number of points** as -3000, 12000 and 31 respectively. Enter the **y Minimum (m)**, **Maximum (m)** and **Number of points** as –3000, 8000 and 31 respectively. Enter the **z Minimum (m)**, **Maximum (m)** and **Number of points** as 0, 0 and 1 respectively.

Step 3.6 ***Specify output parameters***

1. Move to the **Output** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Click on the **New** button and choose NO_x as the pollutant from the drop-down list. Select a long term average (by selecting 'LT' in the **Short/Long** column), with an averaging time of 1 hour, and units of $\mu g/m^3$. Check that there is a tick in the **Include** column for NO_x, so that the NO_x concentrations will be calculated for this model run.
3. At the bottom of the screen, ensure that **Groups** output is selected, to calculate output for a group of sources, and, if necessary, select the **All sources** option.

Step 3.7 ***Run ADMS-Airport***

1. From the **File** menu choose **Save As…**, enter a new file name, e.g. *example9a.upl*, and browse to the directory where you would like to save the file. It is *not* recommended to save files in the model installation directory. Click **OK** to save the file.
2. Run the model by choosing **Run!** from the menu bar.

Step 3.8 ***Using ADMS Mapper to view ADMS-Airport sources***

1. From the **Utilities** menu select **ADMS Mapper** to launch the ADMS Mapper. The Mapper window will display the sources and the output grid extent layers from the file that is open in ADMS-Airport. If not, click on the **Refresh Layers** button, , to refresh the view.

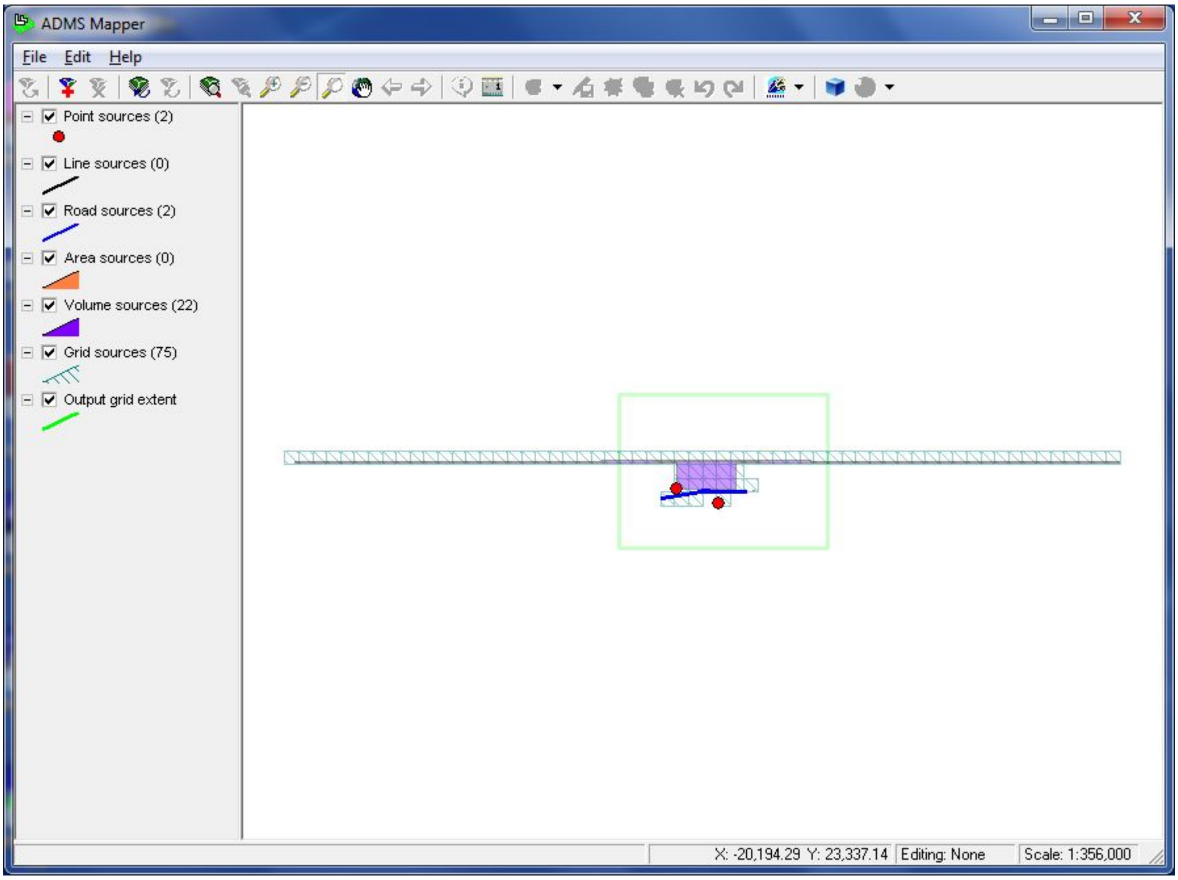


Figure 6.9 – Example 9 ADMS-Airport Sources.

Step 3.9 ***Viewing contour output in ADMS Mapper***

1. In the ADMS Mapper, click on the **Contour** button, .
2. Select **Long term** in the top left of the window and the *example9a.glt* output file from the list at the left of the **Contour Plotting** screen.
3. In the **Dataset to plot** box, choose NO_x concentration from the source group <All sources>.
4. Click on **Advanced Options...** to bring up the **Advanced Contour Options** screen.
5. Check the **Specify number of grid lines** option and specify 400 for each direction. Click on **Close** to return to the ADMS Contour Plotter.
6. Click on the **Plot** button and ensure that the sources and contour plot can be seen.

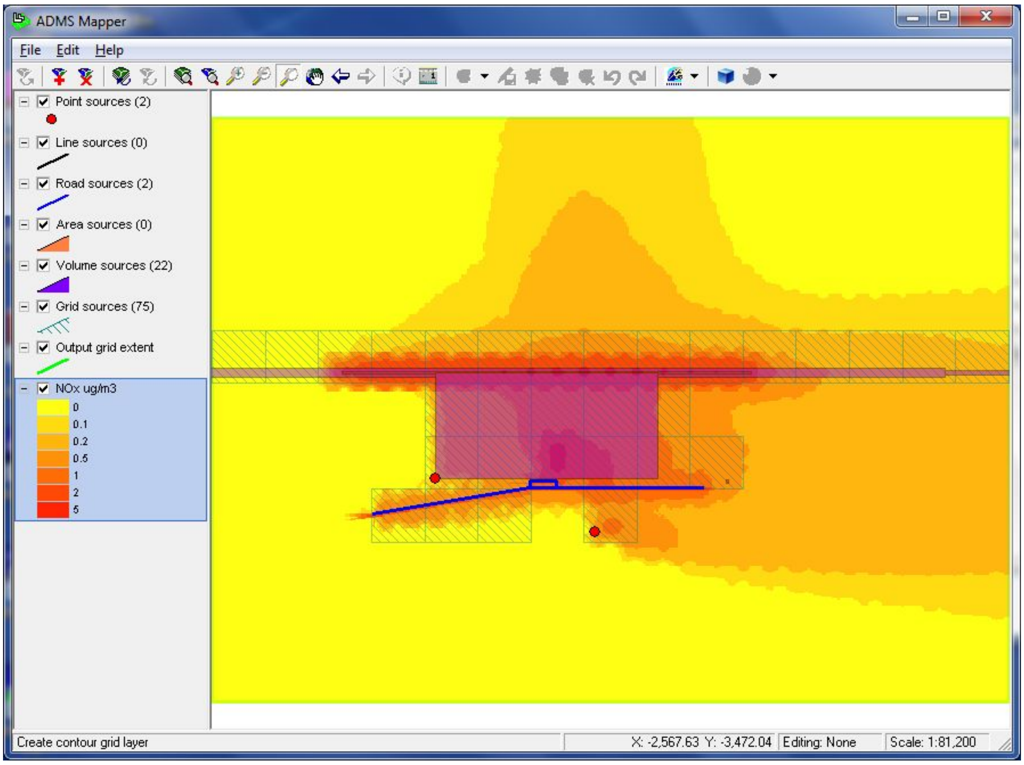


Figure 6.10 – Example 9a NO_x contour plot for a simple airport

Step 3.10 ***Enhancing concentration results around aircraft volume sources***

1. The results currently show that the runway concentrations are quite a lot lower than those from the road. Since source-oriented gridding was selected for road, line and aircraft sources, the roads are treated as regions with high concentration gradients. There were additional receptor points located around the roads and therefore a better resolution is achieved. The aircraft sources were described with industrial volume sources and there are no further points added around the runway.

   A better resolution around the runway can be achieved by defining additional receptor points around the aircraft volume sources.

2. Move to the **Grids** screen by clicking on the tab at the top of the ADMS-Airport window.
3. Select **Both** for the output type.
4. Tick the **Specified Point File** box. Click the **Browse** button and navigate to the file *Example9b.asp* which is in the *Data\Example9* directory in your ADMS-Airport installation directory. The .asp file contains a list of specified points. It is possible to view the .asp file by clicking the **View** button. The points used to construct the contour plots are shown in **Figure 6.11**.

5. From the toolbar select **File**, **Save As…**. Enter a new file name, e.g. *example9b.upl*, and browse to the directory where you would like to save the file.

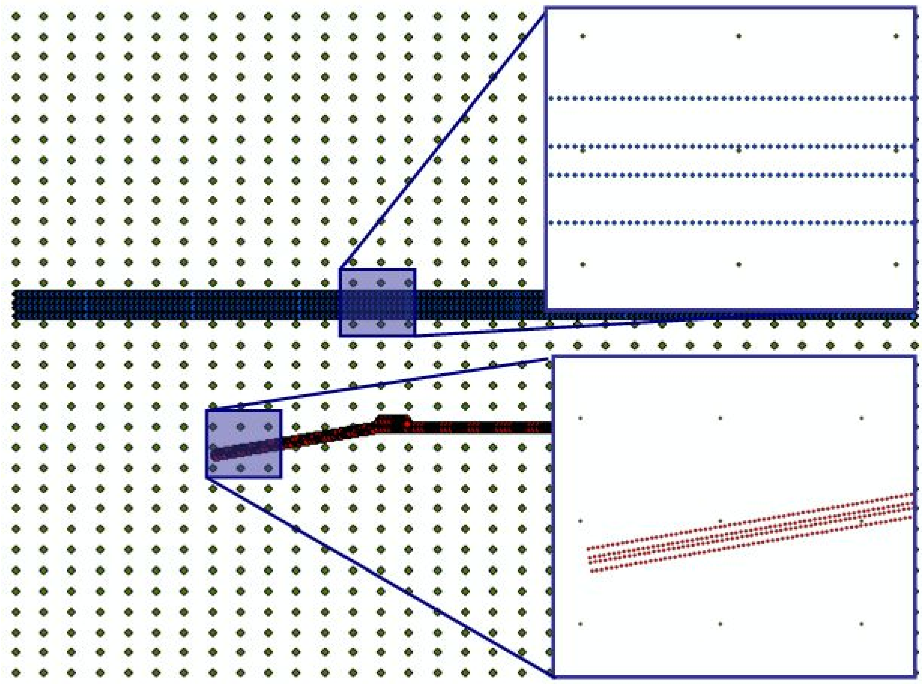


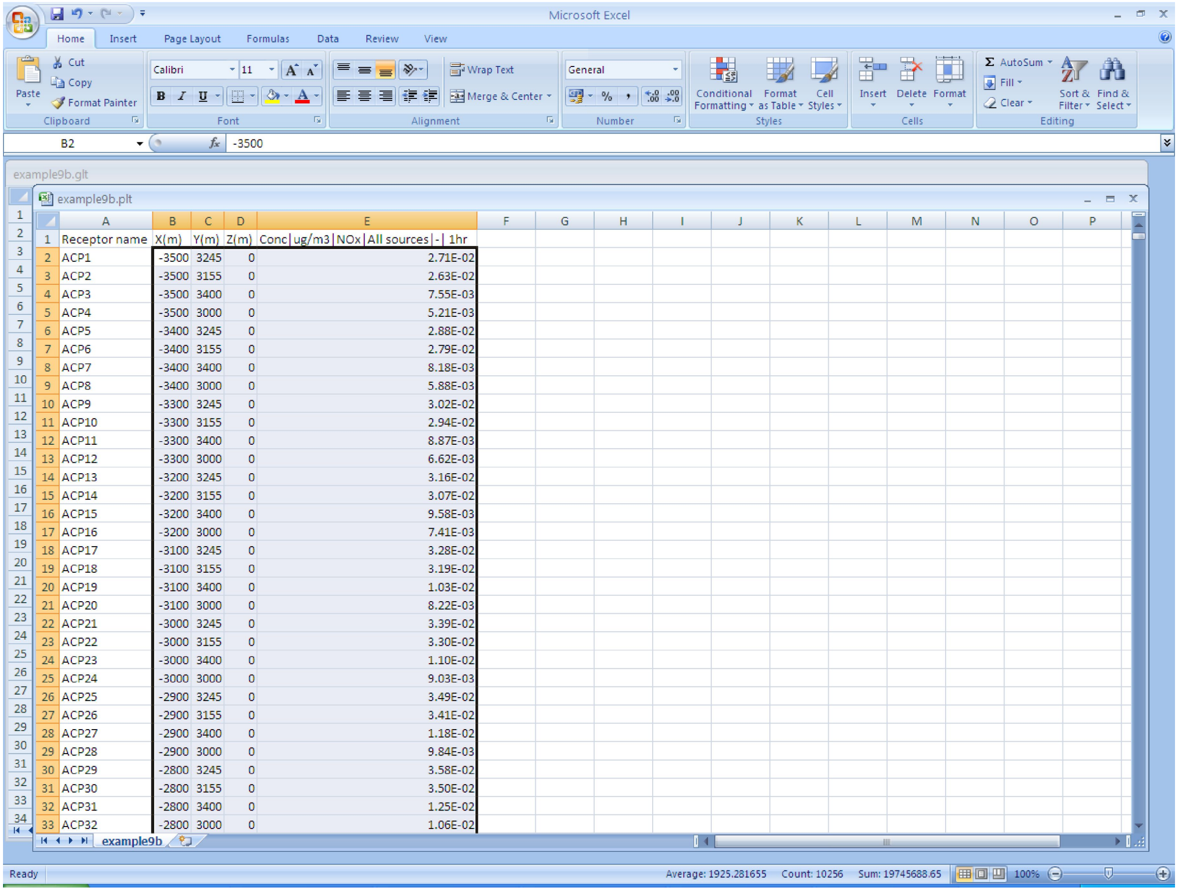
Figure 6.11 – Example 9 receptor locations for generation of contour plots
Regular grid point, Source-oriented (road) grid point, Additional specified point

Step 3.11 ***Run ADMS-Airport***

1. Run the model by choosing **Run!** from the menu bar.

Step 3.12 ***Compiling result to include additional specified points***

1. Open the *example9b.glt* and *example9b.plt* files in **Microsoft Excel**.
2. For each file in turn highlight column A, from the **Data** menu select **Text to Columns…** option. Select **Delimited** and click **Next >**. Select the Delimiter as **Comma** and click **Next >**. Then select **Finish**.
3. Now append the *.plt* results to the *.glt* results by copying all the x, y, z and concentration information as shown in **Figure 6.12**. Now paste this data to the bottom of the *.glt* file.
4. Save this new file as a *comma-delimited* file named *example9b_+AdditionalPoints.glt*.



Receptor name	X(m)	Y(m)	Z(m)	Conc|ug/m3|NOx|All sources|-| 1hr
ACP1	-3500	3245	0	2.71E-02
ACP2	-3500	3155	0	2.63E-02
ACP3	-3500	3400	0	7.55E-03
ACP4	-3500	3000	0	5.21E-03
ACP5	-3400	3245	0	2.88E-02
ACP6	-3400	3155	0	2.79E-02
ACP7	-3400	3400	0	8.18E-03
ACP8	-3400	3000	0	5.88E-03
ACP9	-3300	3245	0	3.02E-02
ACP10	-3300	3155	0	2.94E-02
ACP11	-3300	3400	0	8.87E-03
ACP12	-3300	3000	0	6.62E-03
ACP13	-3200	3245	0	3.16E-02
ACP14	-3200	3155	0	3.07E-02
ACP15	-3200	3400	0	9.58E-03
ACP16	-3200	3000	0	7.41E-03
ACP17	-3100	3245	0	3.28E-02
ACP18	-3100	3155	0	3.19E-02
ACP19	-3100	3400	0	1.03E-02
ACP20	-3100	3000	0	8.22E-03
ACP21	-3000	3245	0	3.39E-02
ACP22	-3000	3155	0	3.30E-02
ACP23	-3000	3400	0	1.10E-02
ACP24	-3000	3000	0	9.03E-03
ACP25	-2900	3245	0	3.49E-02
ACP26	-2900	3155	0	3.41E-02
ACP27	-2900	3400	0	1.18E-02
ACP28	-2900	3000	0	9.84E-03
ACP29	-2800	3245	0	3.58E-02
ACP30	-2800	3155	0	3.50E-02
ACP31	-2800	3400	0	1.25E-02
ACP32	-2800	3000	0	1.06E-02

Figure 6.12 – Example 9b copying *.plt* results to append to a *.glt* file

Step 3.13 ***Viewing results in ADMS Mapper***

1. Return to the ADMS Mapper.
2. Delete the example9a contour layer by clicking on the layer in the left hand legend and selecting **Remove layer** from the **File** menu.
3. Click on the **Contour** button, , to view contours of concentration from the results file you compiled in Step 3.12.
4. Select **Long term** in the top left of the window and the *example9b_+AdditionalPoints.glt* results file from the list at the left of the **Contour Plotting** screen.
5. In the **Dataset to plot** box, the NO_x concentration from the source group <All sources> should already be selected. The **Grid settings** should indicate **400 x 400 grid lines**. These settings can be changed by clicking on **Advanced Options…** .
6. Click on the **Plot** button and the **Save Surfer Grid File As…** screen will be displayed. Browse to an appropriate location (it is best to save the file with your other ADMS-Airport input/output files) and click **Save.**
7. The pollutant concentrations contour will now be displayed in the ADMS Mapper.

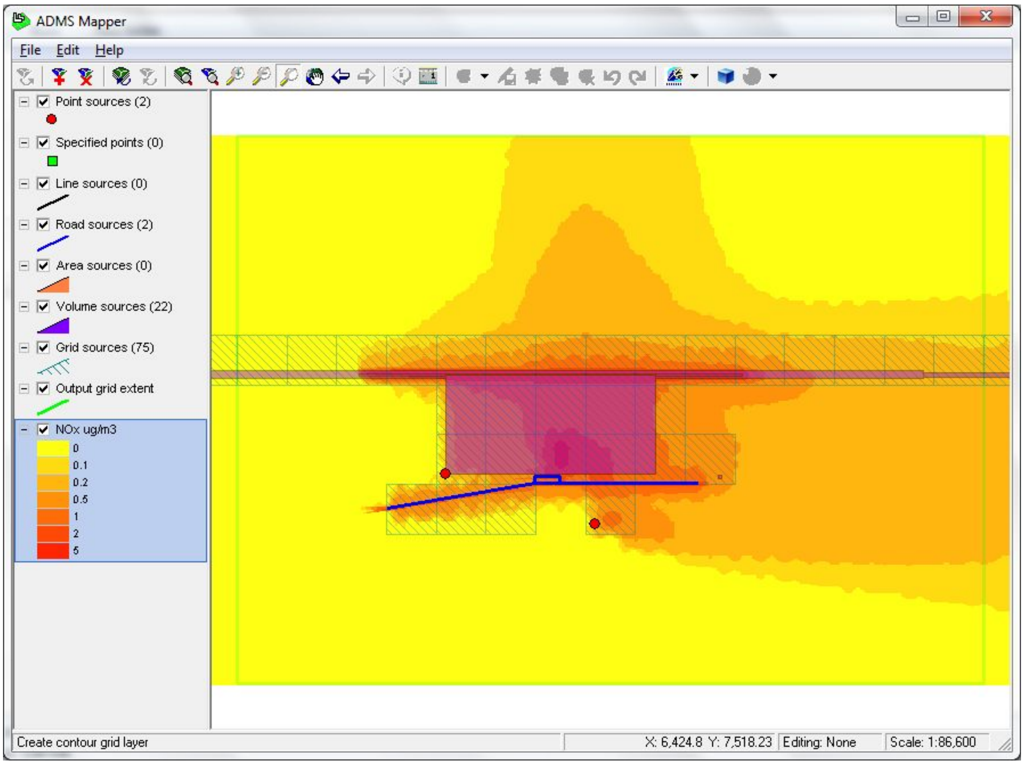


Figure 6.13 – Example 9b NO_x contour plot for a simple airport

Example 10: Modelling a Complex Airport

In this example you will model a complex airport using EMIT and ADMS-Airport for a single day. In particular you will learn:

- how to enter airport emission sources into emission groups in EMIT;
- how to calculate emissions for the complete inventory in EMIT;
- how to convert an EMIT database into an emissions inventory for import into ADMS-Airport;
- how to add source data from an emissions inventory;
- how to import an **Air File** into ADMS-Airport;
- how to implement time-varying emissions;
- how to implement non-standard source-oriented grid options; and
- how to plot results in ArcGIS.

A description of the airport to be modelled follows.

Airport sources considered

This example includes airport sources as described in Section 4 of this User Guide. The following emission sources will be considered:

- Aircraft main engine emissions: approach, landing, deceleration, taxi in, taxi out, take-off, initial climb and climb out;
- Aircraft APU emissions;
- Aircraft GSE emissions, from GSE only, no airside vehicles;
- Airport static source emissions; and
- Urban emissions.

Airport layout

Figure 6.14 shows the airport layout, with runways, taxiways, stands, roads and car parking.

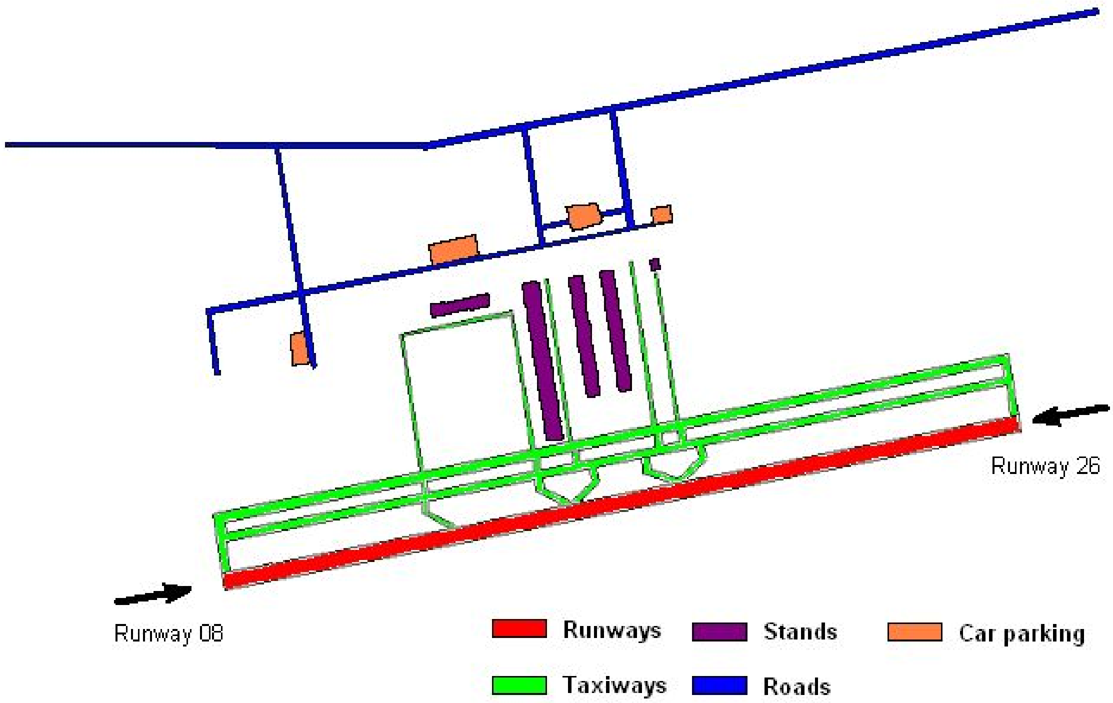


Figure 6.14 – Example 10 airport layout.

Aircraft operations

The data provided represents aircraft movements for a small regional type of airport with in the region of 100,000 aircraft movements annually. A more detailed description of the airport is given in terms of:

- aircraft types operating at the airport, **Table 6.17**
- the aircraft use of the runways, **Table 6.18**
- the aircraft use of the stands, **Table 6.19**
- the temporal distribution of daily aircraft movements for a single day, **Figures 6.15** and **6.16**

Modelling of Aircraft

The aircraft operating at the airport have been used to form the basis for the aircraft modelling categories in the top of the **Air File**. The aircraft categories used are described in **Table 6.21**. The assignment of the aircraft operating at the airport into these categories is shown in **Table 6.20**.

Aircraft Type	Aircraft code	% Arrivals	% Departures	% Movements
Embraer 145	E145	20.3%	19.6%	19.9%
De Havilland 8C	DH8C	16.9%	16.8%	16.8%
Boeing 737-500	B735	10.1%	9.8%	10.0%
Embraer 170	E170	7.4%	10.5%	8.9%
Boeing 737-400	B734	7.4%	4.9%	6.2%
Airbus A319	A319	5.4%	4.9%	5.2%
Airbus A320	A320	4.1%	4.9%	4.5%
McDonnell Douglas MD11	MD11	4.1%	4.2%	4.1%
Let 410	L410	2.7%	3.5%	3.1%
Canadair Regional Jet RJ2	CRJ2	2.7%	2.8%	2.7%
Boeing 737-300	B733	2.7%	2.1%	2.4%
British Aerospace 146-200	B462	2.0%	2.1%	2.1%
Boeing 767-300	B763	2.0%	1.4%	1.7%
Airbus A340-300	A343	1.4%	1.4%	1.4%
Boeing 757-200	B752	1.4%	1.4%	1.4%
Embraer 120	E120	1.4%	1.4%	1.4%
McDonnell Douglas MD87	MD87	1.4%	1.4%	1.4%
De Havilland 8D	DH8D	0.7%	1.4%	1.0%
Piper 34	PA34	1.4%	0.7%	1.0%
Other - 7 aircraft		5%	5%	5%

Table 6.17 – Example 10 aircraft movements at airport.

Runway	Arrivals	Departures
08	20%	18%
26	80%	82%

Table 6.18 – Example 10 aircraft movement use of runways.

Stand Group	% Arrivals	% Departures
1	1%	1%
2	24%	25%
3	34%	36%
4	28%	25%
5	12%	13%

Table 6.19 – Example 10 aircraft movement use of stands, stands are labelled 1 to 5 from left to right in **Figure 6.14**.

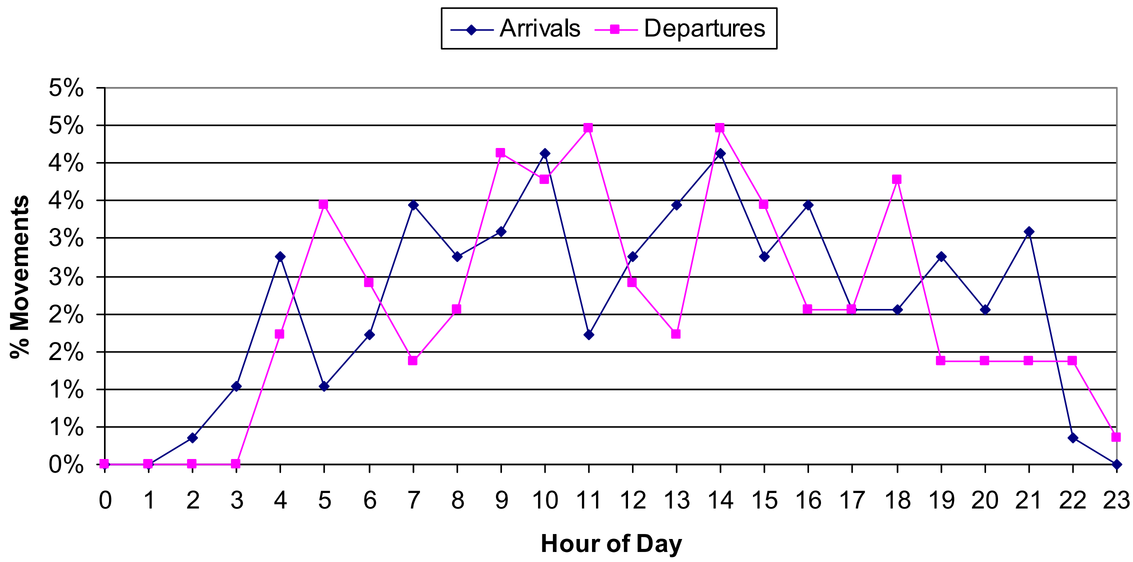


Figure 6.15 – Example 10 temporal distribution of daily aircraft movements for given met data.

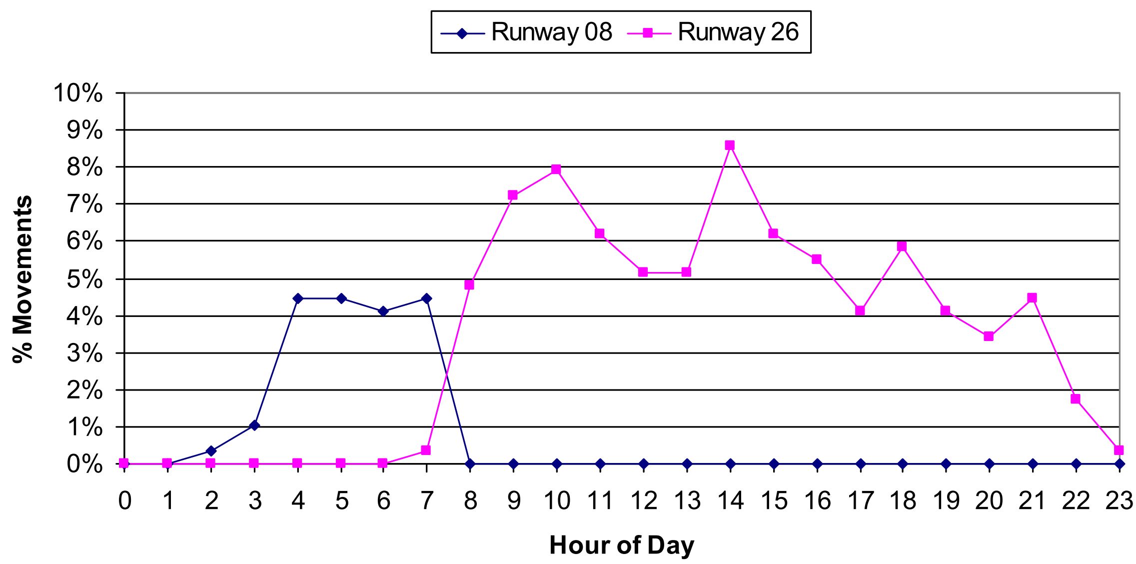


Figure 6.16 – Example 10 temporal distribution of daily aircraft movements between runways for given met data.

Aircraft Modelling Categories									
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
C550		MD11	B763	A318	CRJ2	A343	B462	B737	E145
DH8C			B772	A319	CRJ7	B744		B738	E170
DH8D				A320	MD87				
E120				B733					
L410				B734					
PA34				B735					
				B752					

Table 6.20 – Assignment of aircraft to Aircraft Modelling Categories for example 10

Aircraft Modelling Category	Description of Group	Aircraft/Engine Combination For Exhaust Conditions
0	• Piston aircraft • Turboprop aircraft • Business jet aircraft	N/A
1	• Large jet aircraft • Aircraft with 4 wing-mounted engines • Old engine technology	Boeing 747-200 CF6-50E2
2	• All size jet aircraft • Aircraft with 3 engines • All engine technologies	McDonnell Douglas MD11 PW4x62
3	• Medium and large jet aircraft • 2 wing-mounted engines, • All engine technologies	Airbus A330 Trent 772
4	• Small and regional jet aircraft • 2 wing-mounted engine • Old and current engine technologies	Boeing 737-700 CFM56-3C1
5	• Small and regional jet aircraft • 2 fuselage-mounted engines • Old and current engine technologies	McDonnell Douglas MD87 JT8D-217C
6	• Large jet aircraft • 4 wing-mounted engines • Current engine technology	Boeing 747-700 RB211-524GH
7	• Regional jet aircraft • 4 wing-mounted engines • Current engine technology	Regional jet RJ85 LF507-1F, -1H
8	• Small jet aircraft • 2 wing-mounted engines • New engine technology	Boeing 737-800 Reconditioned Trent 500
9	• Regional jet aircraft • 2 fuselage-mounted engines • New engine technology	Embraer 145 AE3007A1

Table 6.21 – Aircraft Modelling Categories for example 10

APU and GSE

The APU and GSE operating times provided complement the aircraft operations described, these are shown in **Tables 6.22** and **6.23**, split by stand group.

APU Type	APU PARAM ID	Stand Group					All Stands
		1	2	3	4	5	
APU 131-9	APU0001	0	0	110	0	0	110
APU GTCP 331-350	APU0005	0	0	0	183	0	183
APU GTCP 36-100	APU0007	0	0	110	0	0	110
APU GTCP 36-150[ ]	APU0008	0	3247	402	110	2502	6260
APU GTCP 36-150[RR]	APU0009	0	0	146	0	0	146
APU GTCP 36-300 (80HP)	APU0010	0	479	274	438	0	1191
APU GTCP 85 (200 HP)	APU0013	0	0	37	0	0	37
APU GTCP331-200ER (143 HP)	APU0017	240	160	0	237	0	636
APU GTCP331-500 (143 HP)	APU0018	0	0	91	0	0	91
APU GTCP85-129 (200 HP)	APU0020	0	2795	846	852	160	4651
APU GTCP85-98 (200 HP)	APU0021	0	0	0	110	0	110
APU PW901A	APU0023	0	0	91	0	0	91
APU TSCP700-4B (142 HP)	APU0028	399	0	183	274	0	855

Table 6.22 – APU annual operating times at each stand group in hours

GSE Type	GSE PARAM ID	Stand Group					All Stands
		1	2	3	4	5	
Baggage Belt loader	GSEEF012	389	1843	2817	5718	0	10768
Baggage Cart Tractor	GSEEF013	231	7294	6935	13797	3504	31761
Cabin Cleaning Truck	GSEEF015	61	365	487	1034	0	1947
Cabin Cleaning Van	GSEEF016	61	365	487	1034	0	1947
Cabin Cleaning Vehicle	GSEEF017	0	730	1065	213	548	2555
Cargo Delivery	GSEEF019	426	183	1703	2981	0	5293
Cargo Loader	GSEEF020	249	894	1582	3133	0	5858
Cargo Loader large	GSEEF021	274	61	1095	1673	0	3103
Catering Truck	GSEEF022	49	876	1241	937	438	3541
Cleaning Generator large	GSEEF026	183	183	730	1278	0	2373
Cleaning Generator small	GSEEF025	30	335	365	821	0	1551
Fork Lift	GSEEF023	12	432	572	383	219	1618
GPU	GSEEF008	414	6838	0	0	3285	10536
GSE/GA Fuel Truck	GSEEF024	0	1265	0	0	876	2141
Large Fork Lift	GSEEF027	12	432	572	383	219	1618
Lavatory Truck	GSEEF028	103	1125	1722	1521	548	5019
Line Maintenance Truck	GSEEF029	73	1314	1862	1405	657	5311
Mobile Air Starter / Air Climate Unit	GSEEF009	61	0	243	426	0	730
Narrowbody Towbarless Aircraft Tug	GSEEF031	0	0	4289	2646	0	6935
Passenger Stairs	GSEEF032	268	1472	377	779	0	2896
Refuelling Dispenser Truck	GSEEF033	0	0	2811	5262	0	8073
Refuelling Tanker Truck	GSEEF034	456	1521	2628	438	0	5043
Water Truck	GSEEF035	103	1095	1722	1369	548	4836
Widebody Towbarless Aircraft Tug	GSEEF036	0	0	365	639	0	1004

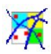
Table 6.23 – GSE annual operating times at each stand group in hours

Other sources

Other sources include the airport power plant, the roads outside the airport perimeter and the airport car parking facilities. These sources complement the aircraft operations described.

These other sources are not explained further here, because they are not specific to an airport.

Step 4.1 ***Start EMIT and create a new emissions inventory***

1. Start EMIT by double-clicking on the  icon.

2. From the File menu choose **New,** enter a new file name e.g. *example10.mdb*, and browse to the directory where you would like to save the file. Click **Save** to save the file.
3. Create a new inventory by clicking **New**.
4. Enter the name and a description of the inventory.

Step 4.2 ***Adding emission groups to an EMIT emissions inventory***

1. From the **Data** menu select **Groups**.
2. Enter a new group by clicking **New...**. Enter the group name Aircraft Approach All MCATs. Select **Volume** from the **Source Type** dropdown menu. Ensure that the button **Enter emissions manually** is selected. Set the **Year** to 2008. Click **OK**.
3. Add further new groups as detailed in **Table 6.24**. Once complete, click **Close**.
4. Click **Add...**, from the **Group** dropdown menu select the group named Aircraft Approach All MCATs then click **Add**. A message “New inventory contents have been saved” appears, click **OK**. Repeat this for each of the groups in **Table 6.24**. Once all source groups are added click **Close**.
5. Return to the inventory overview screen by clicking **Close** in the group overview screen.

Group	**Source Type**	**Emissions**	**EMIT factors**	**Greenhouse Gas Sector**	**Year**	**Fleet Components**	**Route Type**
Aircraft Approach All MCATs	VOLUME	Enter emissions manually			2008		
Aircraft ClimbOut All MCATs	VOLUME	Enter emissions manually			2008		
Aircraft Deceleration MCAT 0	VOLUME	Enter emissions manually			2008		
Aircraft InitialClimb MCAT 0	VOLUME	Enter emissions manually			2008		
Aircraft Landing MCAT 0	VOLUME	Enter emissions manually			2008		
Aircraft Takeoff MCAT 0	VOLUME	Enter emissions manually			2008		
Aircraft TaxiIn All MCATs	VOLUME	Enter emissions manually			2008		
Aircraft TaxiOut All MCATs	VOLUME	Enter emissions manually			2008		
Aircraft APUs	VOLUME	Calculate with emissions factors	APU 2004		2004		
Aircraft GSE	VOLUME	Calculate with emissions factors	AIRPORT GSE 2007		2007		
Airside Vehicles	--Not to be modelled--						
Airport Power Plant	POINT	Enter emissions manually		Energy	2008		
Roads&Parking_ Mobile	ROAD	Calculate with emissions factors	EURO 2009 Urban		2008	LAEI inventory (11)	EU 09 LAEI Urban 08
Roads&Parking_ Hot&Cold_Area	AREA	Calculate with emissions factors	UKEFD03 Road HotCold		2003		
Roads&Parking_ Hot&Cold_Vol	VOLUME	Calculate with emissions factors	UKEFD03 Road HotCold		2003		

Table 6.24 – Example 10 group details.

Step 4.3 ***Adding aircraft sources to an EMIT emission group using the import wizard***

1. Return to the inventory overview screen by clicking **Close** in the group overview screen.
2. From the **File** menu select **Import Data**.
3. Click **Browse…** and select the *Approach_All_MCATs.csv* file which can be found in the *\Data\Example10* directory in your installation directory. Click **Open** and then click **Next >**.
4. Select the emissions inventory, then select the *Aircraft Approach All MCATs* group as the destination EMIT group. Click **Next >**.
5. Ensure that all fields are selected for import. Click **Next >**.

6. You will find that each of that field names correspond to pollutants. Select Emissions units of g/s and then select **Next >**.
7. Some optional fields are missing from the input file, select **Next >** to continue.
8. A list of the fields to be imported is shown, select **Next >** to continue.
9. Click **Next >** to carry out checks of the data before import to EMIT.
10. Click **Import Now** to import the data into EMIT.
11. Click **Exit** to exit the EMIT import wizard.
12. Repeat this process for the remaining source groups given in **Table 6.25**.

Group	EMIT Import File Name	Note
Aircraft Approach All MCATs	Approach_All_MCATs.csv	
Aircraft ClimbOut All MCATs	ClimbOut_All_MCATs.csv	
Aircraft Deceleration MCAT 0	Decelerate_MCAT_0.csv	
Aircraft InitialClimb MCAT 0	InitialClimb_MCAT_0.csv	
Aircraft Landing MCAT 0	Landing_MCAT_0.csv	
Aircraft Takeoff MCAT 0	Takeoff_MCAT_0.csv	
Aircraft TaxiIn All MCATs	TaxiIn_All_MCATs.csv	
Aircraft TaxiOut All MCATs	TaxiOut_All_MCATs.csv	
Aircraft APUs	APU.csv	Assume export field names are correctly assigned on input
Aircraft GSE	GSE.csv	Assume export field names are correctly assigned on input
Roads&Parking_Mobile	Roads&Parking_Mobile.csv	Assume export field names are correctly assigned on input
Roads&Parking_Hot&Cold_Area	Roads&Parking_Hot&Cold_Area.csv	Assume export field names are correctly assigned on input
Roads&Parking_Hot&Cold_Vol	Roads&Parking_Hot&Cold_Vol.csv	

Table 6.25 – Example 10 EMIT import wizard file names.

Step 4.4 ***Adding source emissions to EMIT manually***

1. Input power plant source emissions as described in **Table 6.26**.

Source Group	Source Name	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°C)	Emissions (tonnes per year)					Vertices	
						CO	NO_x	PM_{10}	SO_2	VOC	X1	Y1
Airport Power Plant	Power Plant	25	1.8	10	130	7.2	34.8	1.44	70.2	0.362	900	1425

Table 6.26 – Example 10 source and vertex details for point sources.

Step 4.5 ***Calculating emissions for the complete EMIT emissions inventory***

1. Set up the geographical extents of the EMIT emissions inventory by clicking **Inventory Properties…** in the source group overview window.

2. In the boxes **South West** set **X** to -30000 and **Y** to -7000. In the boxes **North East** set **X** to 32000 and **Y** to 7000. Click **OK**.
3. Ensure that the **Annual average emissions** button is selected.
4. Click **Calculate** to calculate total emissions for all source groups in the inventory over the selected extents.
5. Click **View Totals**, the total emissions should be as given in Table 6.27.
6. Click **Close** to exit the total emissions screen.

Group	BENZENE	BUTADIENE	CO	NO2	NOx	PM10	PM2.5	SO2	VOC	CO2
Aircraft Approach All MCATs	-	-	6.56E+01	1.25E+00	8.36E+00	2.15E-01	-	1.42E+00	6.48E+00	5.59E+03
Aircraft APUs	-	-	1.26E+01	6.28E-01	6.28E+00	-	-	-	1.10E+00	-
Aircraft ClimbOut All MCATs	-	-	3.12E+00	4.03E+00	7.61E+01	5.95E-01	-	2.81E+00	1.52E-01	1.11E+04
Aircraft Deceleration MCAT 0	-	-	1.54E-01	4.59E-02	3.06E-01	2.61E-03	-	2.46E-02	3.28E-03	9.69E+01
Aircraft InitialClimb MCAT 0	-	-	7.09E-01	1.28E-01	2.42E+00	1.07E-02	9.84E-01	1.13E-01	4.75E-03	4.44E+02
Aircraft Landing MCAT 0	-	-	1.06E+00	2.55E-01	1.70E+00	1.36E-02	-	1.40E-01	6.78E-02	5.53E+02
Aircraft Takeoff MCAT 0	-	-	3.61E-01	8.32E-02	1.57E+00	6.38E-03	-	7.30E-02	2.81E-02	2.88E+02
Aircraft TaxiIn All MCATs	-	-	7.04E+01	5.24E+00	1.40E+01	6.12E-01	-	2.46E+00	5.63E+00	9.69E+03
Aircraft TaxiOut All MCATs	-	-	1.32E+02	9.65E+00	2.57E+01	1.24E+00	-	4.64E+00	1.06E+01	1.83E+04
Airport GSE	-	-	7.56E+00	6.51E-01	1.30E+01	9.84E-01	-	-	1.89E+00	0.00E+00
Power Plant	-	-	7.20E+00	1.74E+00	3.48E+01	1.44E+00	-	7.02E+01	3.62E-01	-
Roads&Parking_ Hot&Cold_Area	3.98E-02	7.10E-03	9.87E+00	5.55E-02	5.55E-01	1.38E-02	1.38E-02	-	7.03E+00	-
Roads&Parking_ Hot&Cold_Volume	2.93E-02	6.29E-03	8.75E+00	4.92E-02	4.92E-01	1.22E-02	1.22E-02	-	2.54E+00	-
Roads&Parking_ Mobile	1.74E-01	1.35E-01	5.531E+01	4.09E+00	2.07E+01	7.11E-01	6.76E-01	2.20E-01	6.66E+00	7.14E+03
TOTAL	**2.43E-01**	**1.48E-01**	**3.75E+02**	**2.79E+01**	**2.06E+02**	**5.85E+00**	**1.69E+00**	**8.21E+01**	**4.25E+01**	**5.32E+04**

Group	METHANE	N2O	NH3	B[a]P
Roads&Parking_ Mobile	3.87E-01	2.43E-01	1.73E+00	1.16E-04
TOTAL	**3.87E-01**	**2.43E-01**	**1.73E+00**	**1.16E-04**

Table 6.27 – Example 10 EMIT annual emissions.

The total annual airport emissions are a combination of the airport emissions input via EMIT and input via AIR file.

Step 4.6 ***Export an EMIT emissions inventory for import into ADMS-Airport***

1. In **EMIT** from the source groups overview screen select the Aircraft Approach All MCATs group. Click **Export Group…**, select **To Inventory…** from the dropdown list. Click **New** and name the new inventory *Example10_Inventory.mdb*. Save the inventory to a suitable working location. Ensure that the **All Pollutants** button is checked and click **Export**.
2. Export the remaining source groups to this inventory: Selecting each group in turn, click **Export Group…**, select **To Inventory…** from the dropdown list. If not already selected, click **Browse** to find the file *Example10_Inventory.mdb* just created. Ensure that the **All Pollutants** button is checked and click **Export**.
3. Select **Export Totals**. Export total emissions to *Example10_Inventory.mdb*, set the **Grid Depth** to 10m, and click **Export**. This exports aggregated grids of the emissions from all EMIT sources to the ADMS emissions inventory database.
4. The file *Example10_Inventory.mdb* contains the emissions inventory for import into ADMS-Airport. Click **Close**, from the toolbar select **File** and then **Exit** to exit EMIT.

Step 4.7 ***Start ADMS-Airport and define basic setup data***

1. Start ADMS-Airport by double-clicking on the  icon.
2. Enter the name of the site and the project.

Step 4.8 ***Import source data from an emissions inventory***

1. From the toolbar select **File, Preferences, Inventory Database…**.
2. Select **Browse** to locate the inventory database *example10_Inventory.mdb*, click **Open**, and then click **OK**.
3. Move to the **Source** screen by clicking on the tab at the top of the ADMS-Airport window.
4. Select **Show Road Sources**. Check that the **Current dataset** defined for the road traffic emissions is **UK EFT v5.1 (2 VC)**. If not, click **Change** and select this dataset from the list.

Although the road traffic emissions are imported directly from the emissions inventory and are not recalculated, the **Current dataset** *in the interface must match that in the emissions inventory. EMIT 3.2 saves the road source dataset by default as* **UK EFT v5.1 (2 VC)**.

---

5. From the toolbar select **Emissions Inventory**, **Import from Emissions Inventory**.
6. No pollutants are to be imported from the emissions inventory, click **Next >**.

7. Import all sources from the emissions inventory, by selecting **Add All**, then click **Finish**. The warning message is shown as in **Figure 6.17**, click **OK** to continue.

   Select **Show Industrial Sources** to see that sources have been added.

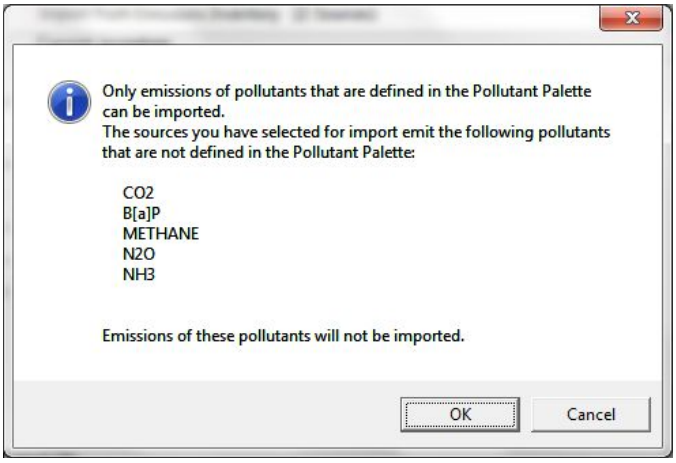


Figure 6.17 – Example 10 warning message when importing sources from an emissions inventory.

Step 4.9 ***Adding aircraft AIR FILE sources***

1. Select the **Show Aircraft Sources** option to display the aircraft source table.
2. Check the box marked **Model aircraft sources**.
3. **Browse** to locate the *.air* file from the *\Data\Example10* directory provided in your ADMS-Airport installation location, click on the file and select **Open**.

Step 4.10 ***Enter meteorological data from a file***

1. Move to the **Meteorology** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Set the Surface roughness to 0.3 m and the latitude to 52º. Make sure that the **Use advanced options** box is ticked, then click the **Data** button and set the Minimum Monin-Obukhov length to 20 m.
3. Select the **From file** option further down the screen. Click on the **Browse** button, and select the file *oneday.met* from the supplied *\Data* directory. This file contains 24 lines of hourly sequential meteorological data.
4. Make sure that the **Met. Data are hourly sequential** box is ticked.

Step 4.11 ***Enter a background concentration***

1. Move to the **Background** screen by clicking on the tab at the top of the ADMS-Airport window.

2. Check that the **None** option is selected.

Step 4.12 ***Define output grids***

1. Move to the **Grids** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Select **Both** output with **Regular** spacing. Select the **Road, Line, Aircraft** option in the **Source-oriented grids** section.
3. Enter the **x Minimum (m)**, **Maximum (m)** and **Number of points** as –1000, 10000 and 50 respectively. Enter the **y Minimum (m)**, **Maximum (m)** and **Number of points** as –1000, 5000 and 30 respectively. Enter the **z Minimum (m)**, **Maximum (m)** and **Number of points** as 0, 0 and 1 respectively.
4. Tick the **Specified Point File** box. Click the **Browse** button and navigate to the file *ReceptorPoints.asp* which is in the *\Data\Example10* directory in your ADMS-Airport installation directory.
5. In this example, you may clear the **Source-oriented grids** options.

Step 4.13 ***Specify output parameters***

1. Move to the **Output** screen by clicking on the tab at the top of the ADMS-Airport window.
2. Click on the **New** button and choose NO_x as the pollutant from the drop-down list. Select a long term average (by selecting 'LT' in the **Short/Long** column), with an averaging time of 1 hour, and units of $\mu g/m^3$. Check that there is a tick in the **Include** column for NO_x, so that the NO_x concentrations will be calculated for this model run.
3. At the bottom of the screen, ensure that **Groups** output is selected, to calculate output for a group of sources, and, make sure that the **All sources** box is ticked.

Step 4.14 ***Add a time-varying emission factors file***

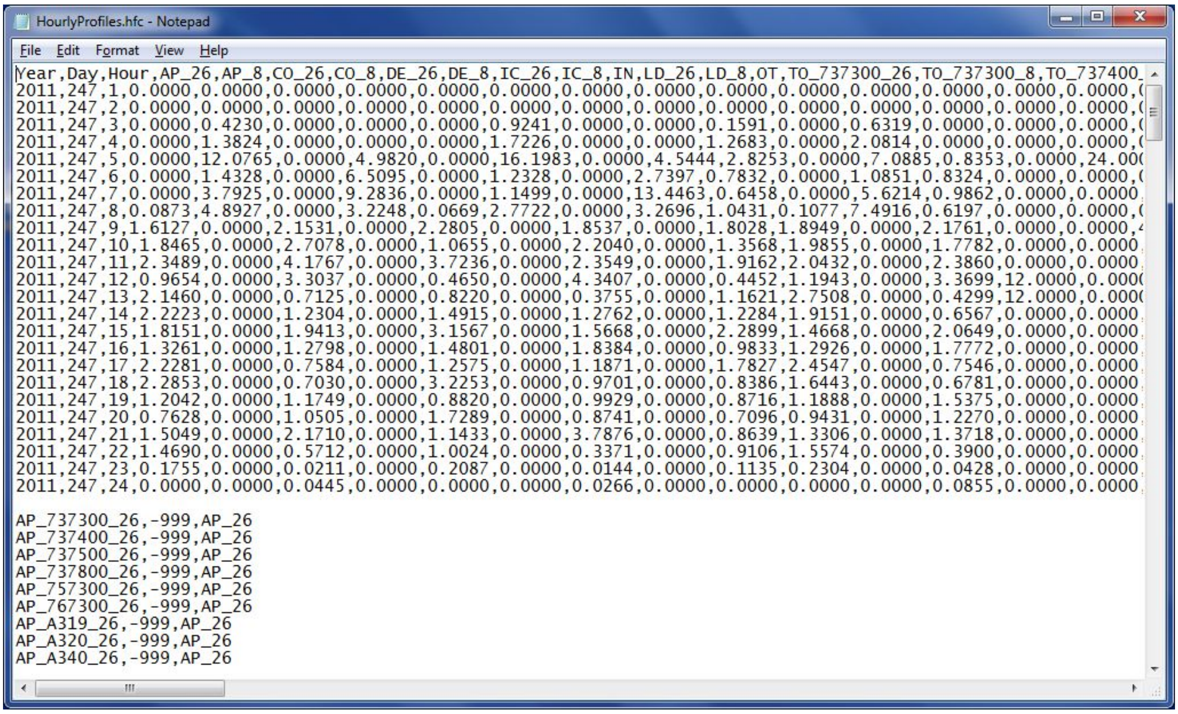
1. In this example a *.fac* file is used with one profile to describe temporal emissions for all roads and parking sources.
2. In the **Source** tab check the **Time varying emission factors** box.
3. Click the **Data source…** button.
4. Ensure that the **File of time varying factors** button is selected and check the *.fac* box. Click the corresponding **Browse…** button to locate the time-varying emission factors file provided, *DiurnalProfiles.fac*.

Step 4.15 ***Add an hourly profiles file***

1. In this example a complex *.hfc* file is used with 54 profiles to describe temporal emissions for:

- Approach, landing, deceleration, initial climb, climb out to/from each runway;
- Take-off by each aircraft type from each runway;
- Inbound and outbound use of the taxiing routes; and
- APU and GSE by stand group.

Figure 6.18 shows the *.hfc* file provided.



HourlyProfiles.hfc - Notepad

File Edit Format View Help

```
Year,Day,Hour,AP_26,AP_8,CO_26,CO_8,DE_26,DE_8,IC_26,IC_8,IN,LD_26,LD_8,OT,TO_737300_26,TO_737300_8,TO_737400_
2011,247,1,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,
2011,247,2,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,
2011,247,3,0.0000,0.4230,0.0000,0.0000,0.0000,0.9241,0.0000,0.0000,0.1591,0.0000,0.6319,0.0000,0.0000,0.0000,
2011,247,4,0.0000,1.3824,0.0000,0.0000,0.0000,1.7226,0.0000,0.0000,1.2683,0.0000,2.0814,0.0000,0.0000,0.0000,
2011,247,5,0.0000,12.0765,0.0000,4.9820,0.0000,16.1983,0.0000,4.5444,2.8253,0.0000,7.0885,0.8353,0.0000,24.00
2011,247,6,0.0000,1.4328,0.0000,6.5095,0.0000,1.2328,0.0000,2.7397,0.7832,0.0000,1.0851,0.8324,0.0000,0.0000,
2011,247,7,0.0000,3.7925,0.0000,9.2836,0.0000,1.1499,0.0000,13.4463,0.6458,0.0000,5.6214,0.9862,0.0000,0.0000
2011,247,8,0.0873,4.8927,0.0000,3.2248,0.0669,2.7722,0.0000,3.2696,1.0431,0.1077,7.4916,0.6197,0.0000,0.0000,
2011,247,9,1.6127,0.0000,2.1531,0.0000,2.2805,0.0000,1.8537,0.0000,1.8028,1.8949,0.0000,2.1761,0.0000,0.0000,
2011,247,10,1.8465,0.0000,2.7078,0.0000,1.0655,0.0000,2.2040,0.0000,1.3568,1.9855,0.0000,1.7782,0.0000,0.0000
2011,247,11,2.3489,0.0000,4.1767,0.0000,3.7236,0.0000,2.3549,0.0000,1.9162,2.0432,0.0000,2.3860,0.0000,0.0000
2011,247,12,0.9654,0.0000,3.3037,0.0000,0.4650,0.0000,4.3407,0.0000,0.4452,1.1943,0.0000,3.3699,12.0000,0.000
2011,247,13,2.1460,0.0000,0.7125,0.0000,0.8220,0.0000,0.3755,0.0000,1.1621,2.7508,0.0000,0.4299,12.0000,0.000
2011,247,14,2.2223,0.0000,1.2304,0.0000,1.4915,0.0000,1.2762,0.0000,1.2284,1.9151,0.0000,0.6567,0.0000,0.0000
2011,247,15,1.8151,0.0000,1.9413,0.0000,3.1567,0.0000,1.5668,0.0000,2.2899,1.4668,0.0000,2.0649,0.0000,0.0000
2011,247,16,1.3261,0.0000,1.2798,0.0000,1.4801,0.0000,1.8384,0.0000,0.9833,1.2926,0.0000,1.7772,0.0000,0.0000
2011,247,17,2.2281,0.0000,0.7584,0.0000,1.2575,0.0000,1.1871,0.0000,1.7827,2.4547,0.0000,0.7546,0.0000,0.0000
2011,247,18,2.2853,0.0000,0.7030,0.0000,3.2253,0.0000,0.9701,0.0000,0.8386,1.6443,0.0000,0.6781,0.0000,0.0000
2011,247,19,1.2042,0.0000,1.1749,0.0000,0.8820,0.0000,0.9929,0.0000,0.8716,1.1888,0.0000,1.5375,0.0000,0.0000
2011,247,20,0.7628,0.0000,1.0505,0.0000,1.7289,0.0000,0.8741,0.0000,0.7096,0.9431,0.0000,1.2270,0.0000,0.0000
2011,247,21,1.5049,0.0000,2.1710,0.0000,1.1433,0.0000,3.7876,0.0000,0.8639,1.3306,0.0000,1.3718,0.0000,0.0000
2011,247,22,1.4690,0.0000,0.5712,0.0000,1.0024,0.0000,0.3371,0.0000,0.9106,1.5574,0.0000,0.3900,0.0000,0.0000
2011,247,23,0.1755,0.0000,0.0211,0.0000,0.2087,0.0000,0.0144,0.0000,0.1135,0.2304,0.0000,0.0428,0.0000,0.0000
2011,247,24,0.0000,0.0000,0.0445,0.0000,0.0000,0.0000,0.0266,0.0000,0.0000,0.0000,0.0000,0.0855,0.0000,0.0000

AP_737300_26,-999,AP_26
AP_737400_26,-999,AP_26
AP_737500_26,-999,AP_26
AP_737800_26,-999,AP_26
AP_757300_26,-999,AP_26
AP_767300_26,-999,AP_26
AP_A319_26,-999,AP_26
AP_A320_26,-999,AP_26
AP_A340_26,-999,AP_26
```

Figure 6.18 – Example 10 ADMS-Airport hourly profile (*.hfc*) file.

2. In the **Time varying emission factors** screen check the **.hfc file** box.
3. Click the corresponding **Browse...** button to locate the time-varying emission factors file provided, *HourlyProfiles.hfc*.
4. Click **OK**.

Step 4.16 ***Using non-standard source-oriented grid point options***

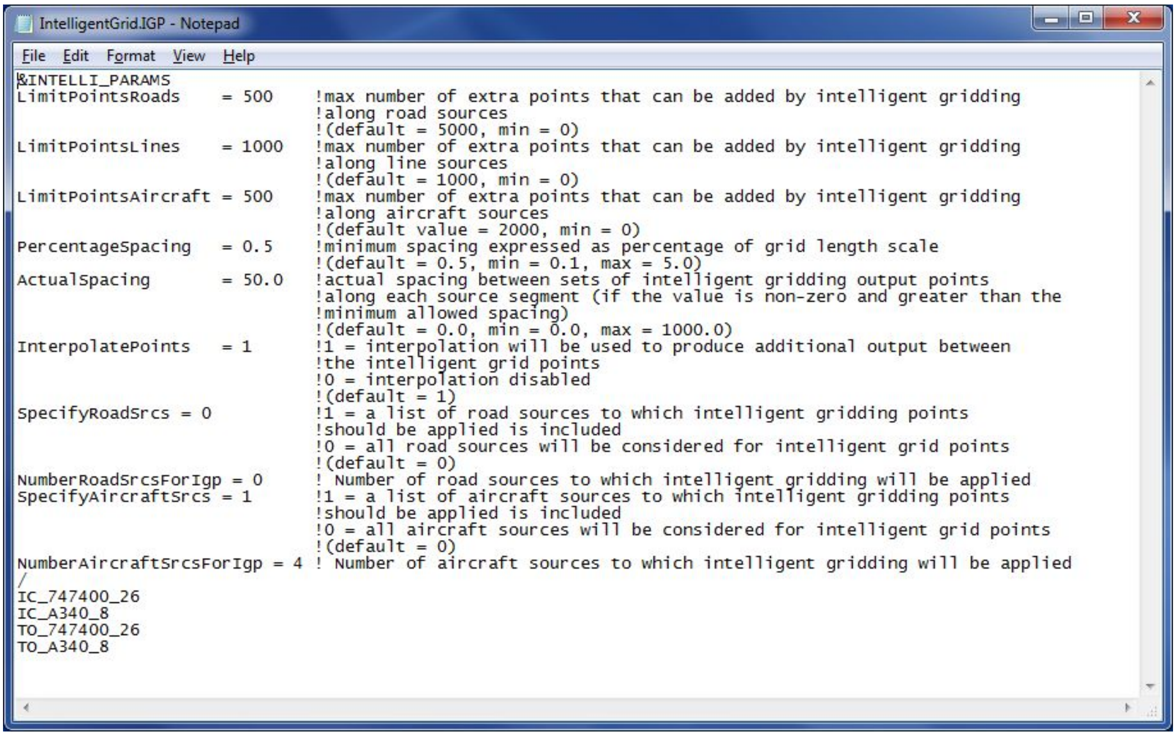
1. In this example since there are many **Air File** sources we wish to use non-default values in the *.igp* file. This will allow us to specify the **Air File** sources to which to apply source-oriented gridding points.

   The following keywords have been changed from their default values:

   - LimitPointsRoads set to 500;
   - LimitPointsAircraft set to 500;
   - ActualSpacing set to 50;
   - SpecifyAircraftSrcs set to 1;

- NumberAircraftSrcsForIgp set to 4; and
- Air file sources to set source-oriented grid points against: IC_747400_26, IC_A340_8, TO_747400_26 and TO_A340_8.

Figure 6.19 shows the *.igp* file provided.



```
&INTELLI_PARAMS
LimitPointsRoads     = 500    !max number of extra points that can be added by intelligent gridding
                              !along road sources
                              !(default = 5000, min = 0)
LimitPointsLines     = 1000   !max number of extra points that can be added by intelligent gridding
                              !along line sources
                              !(default = 1000, min = 0)
LimitPointsAircraft = 500     !max number of extra points that can be added by intelligent gridding
                              !along aircraft sources
                              !(default value = 2000, min = 0)
PercentageSpacing    = 0.5    !minimum spacing expressed as percentage of grid length scale
                              !(default = 0.5, min = 0.1, max = 5.0)
ActualSpacing        = 50.0   !actual spacing between sets of intelligent gridding output points
                              !along each source segment (if the value is non-zero and greater than the
                              !minimum allowed spacing)
                              !(default = 0.0, min = 0.0, max = 1000.0)
InterpolatePoints    = 1      !1 = interpolation will be used to produce additional output between
                              !the intelligent grid points
                              !0 = interpolation disabled
                              !(default = 1)
SpecifyRoadSrcs = 0           !1 = a list of road sources to which intelligent gridding points
                              !should be applied is included
                              !0 = all road sources will be considered for intelligent grid points
                              !(default = 0)
NumberRoadSrcsForIgp = 0      ! Number of road sources to which intelligent gridding will be applied
SpecifyAircraftSrcs = 1       !1 = a list of aircraft sources to which intelligent gridding points
                              !should be applied is included
                              !0 = all aircraft sources will be considered for intelligent grid points
                              !(default = 0)
NumberAircraftSrcsForIgp = 4 ! Number of aircraft sources to which intelligent gridding will be applied
/
IC_747400_26
IC_A340_8
TO_747400_26
TO_A340_8
```

Figure 6.19 – Example 10 ADMS-Airport source-oriented grid point (*.igp*) file.

2. Ensure that the **Additional input file** button is selected on the **Setup** screen and click **Browse** to locate the *.uai* file provided, *AdditionalInput.uai*.
3. Click **Edit** and check that the *.uai* file contains the correct path reference to the *.igp* file, as in **Figure 6.20**

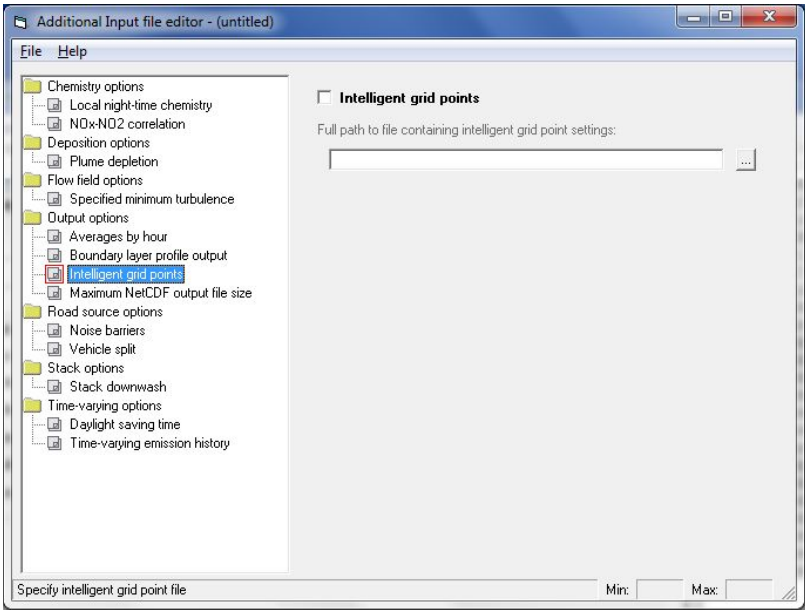


Figure 6.20 – The Additional Input file editor for including an *.igp* file.

Step 4.17 ***Save ADMS-Airport *.upl file***

1. From the **File** menu choose **Save As…**, enter a new file name, e.g. *example10.upl*, and browse to the directory where you would like to save the file. It is *not* recommended to save files in the model installation directory. Click **OK** to save the file.

Step 4.18 ***Run ADMS-Airport***

1. Return to ADMS-Airport.
2. Run the model by choosing **Run!** from the menu bar.

Step 4.19 ***Using ADMS Mapper to view ADMS-Airport sources***

1. From the **Utilities** menu select **ADMS Mapper** to launch the ADMS Mapper. The Mapper window will display the sources and the output grid extent layers from the file that is open in ADMS-Airport. If not, click on the **Refresh Layers** button, , to refresh the view.

Step 4.20 ***Compiling the result to include additional specified points***

1. Open the *example10.glt* and *example10.plt* in **Microsoft Excel**.
2. For each file in turn highlight column A, from the **Data** menu select **Text to Columns…** option. Select **Delimited** and click **Next >**. Select the Delimiter as **Comma** and click **Next >**. Then select **Finish**.
3. Now append the *.plt* results to the *.glt* results by copying all the x, y, z and concentration information, as previously shown in Step 3.11. Now paste this data to the bottom of the *.glt* file.

4. Save this new file as a *comma-delimited* file named *example10_+AdditionalPoints.glt*.

Step 4.21 ***Adding a contour map***

1. In ADMS Mapper, to add a contour to the plot click on the **Contour** button, .
2. Select **Long term** in the top left of the window and select the *example10_+AdditionalPoints.glt* results file from the list at the left of the **Contour Plotting** screen.
3. In the **Dataset to plot** box, the NO_x concentration from the source group <All sources> should already be selected. The **Grid settings** should indicate **100 x 100 grid lines**. These settings can be changed by clicking on **Advanced Options…** .
4. Click on the **Plot** button and the **Save Surfer Grid File As…** screen will be displayed. Browse to an appropriate location (it is best to save the file with your other ADMS-Airport input/output files) and click **Save.**
5. The pollutant concentrations contour will now be displayed in the ADMS Mapper and will look as in **Figure 6.21**.

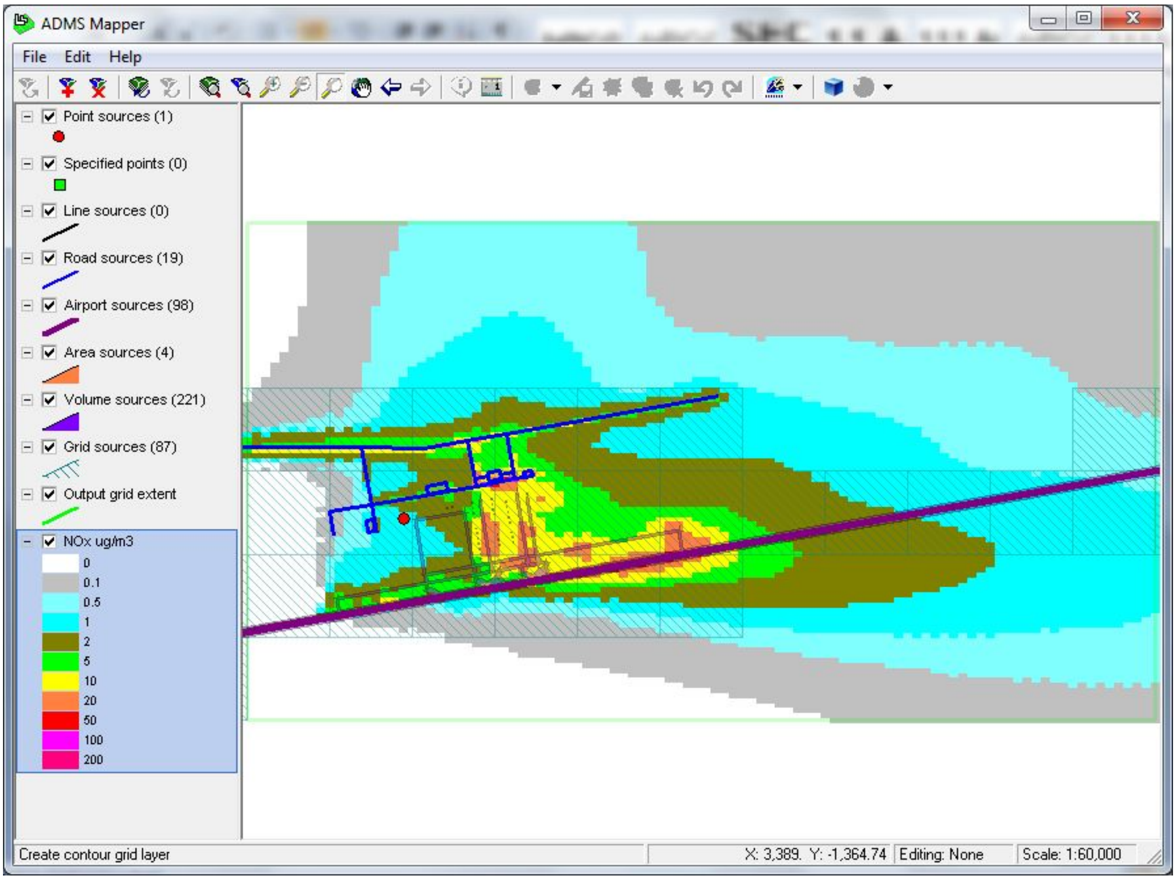


Figure 6.21 – Example 10 NO_x contour plot for a complex airport

Case Study: CAEPport

This case study shows the ADMS-Airport submission to one of the International Civil Aviation Organisation (ICAO) Committee on Aviation Environmental Protection (CAEP) model exercises, **CAEP 2008**. The purpose of this study was to test the candidate models' ability to calculate emissions and the dispersion of pollutants at an airport.

A fictitious generic airport was created for the study known as "CAEPport". This airport did not represent a specific airport, but similarities to real airports could not be discounted. The study presents NO_x concentrations at receptor locations and as contours from four modelling groups for the year 2004. All modelling groups used common airport layout information, airport operation data and meteorological data.

The case study shown presents the inputs, processes and outputs from the ADMS-Airport dispersion model.

CAEPport Layout, Operations and Meteorology

This section gives a summary of CAEPport, including aircraft usage, airport layout, other airport features, emissions inventory, and meteorology inputs.

Airport layout

Figure 6.22 shows the layout of CAEPport with runways, taxiways, stands, terminals, roads and car parks. **Table 6.28** describes the airport features shown on the layout in more detail and indicates whether the emissions from the feature were modelled.

Figure 6.23 shows the output parameters required for the CAEPport study, including 4 receptor locations and the extents for concentration contours. Further details of these parameters are given in **Table 6.29**.

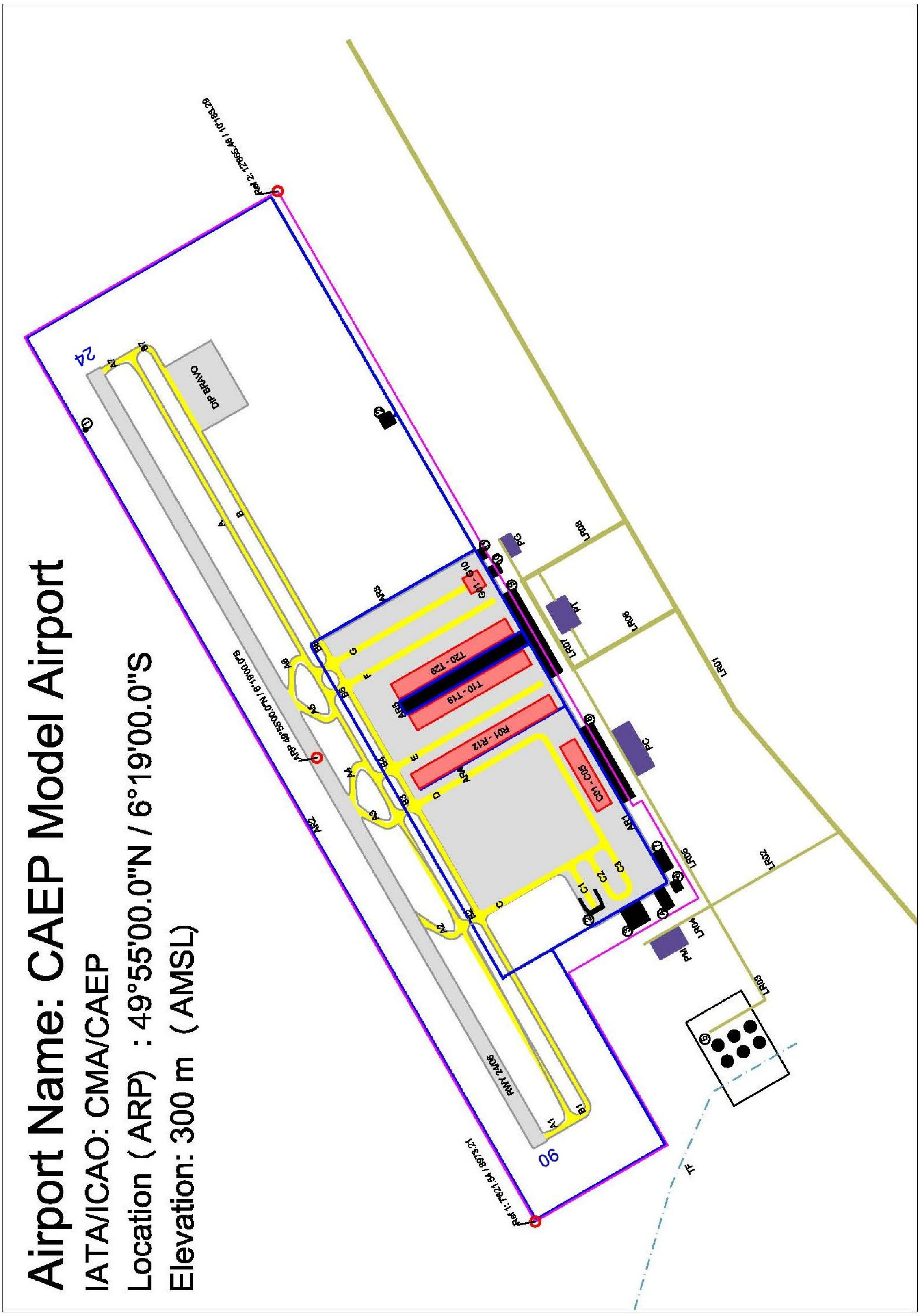


Figure 6.22 – CAEPport case study airport layout

Airport Feature	Description	Modelled
Runway	Runway with multiple rapid exit taxiways.	✔
Taxiways	• main parallel taxiways (A, B), connected to the runway with rapid exit taxiways and access taxiways on each side (A1-A7); • main access taxiways to the aircraft stands (1 to maintenance, 1 to cargo, 1 to remote/pier, 1 to pier, 1 to general aviation; C-G); • 3 secondary access taxiways to the maintenance area (C1-C3).	✔
Apron	Total of 47 aircraft stands: • 5 cargo stands (C01-C05) • 12 remote stands (R01-R12) • 20 pier stands (T01-T29) • 10 general aviation stands (G01-G10) Central De-icing Pad with 2 widebody or 3 narrowbody lanes (DIP-B) for all aircraft de-icing operations.	✔ APU GSE ✕ De-icing
1. Met Instruments	Location of the met sensors that provide meteorological data	✕
2. Engine Run-up Silencer	U-shaped engine run-up silencer for engine test runs	✕
3. Aircraft Maintenance	Maintenance building for servicing, washing, painting, repairing aircraft	✕
4. Catering	Catering facility to provide all necessary amenities for flights	✕
5. Fuel Farm	Kerosene and fuel farm with 5 tanks of kerosene for aircraft and 1 tank of diesel fuel for the power plant. Tanks are equipped with either sealed fixed or sealed floating roofs. Fuel is delivered by electrical block trains; fuel transfer is in a contained system (fuel vapour recovery system).	✔ Kerosene tanks ✕ Diesel tanks
6. Power Plant	Oil fuelled power plant providing electrical and process energy (including heating and cooling) to all airport buildings.	✔
7. Airport Maintenance	Airport maintenance and service facility, containing repair, service, paint shops and vehicle fuel station. This fuel station is for direct fuelling of vehicles and fuelling of tanker trucks for some aircraft.	✕
8. Cargo Building	Cargo exchange building with limited storage capacity	✕
9. Passenger Terminal	Passenger terminal building with pier; gates are equipped with passenger loading bridges.	✕
10. GA Terminal	General Aviation Terminal Building.	✕
11. Fire Station and Emergency Power	Fire station and emergency power station for the airport	✕

Table 6.28 – CAEPport case study airport features.

Airport Feature	Description	Modelled
12. Fire training site	Open fire training site for the airport's fire services with regular fire trainings	✗
13. Air Traffic Control	Control Tower, Technical block and navigation equipment maintenance service	✗
Airside Service Roads	Airside service roads connecting buildings and apron, and perimeter fence road (AR1-AR5).	✗
Landside Access Roads	Landside access roads from main bypass road with access to various parking, kerbside and maintenance facilities and connections to those facilities (LR01-LR09). Roads are either one-way or two way and single lane or multi-lane.	✔
Parking facilities	Various parking facilities with a total of 3,900 parking spaces: • PM: Maintenance Parking (1 level/500 spaces) • PC: Cargo and long-term remote parking (1 level/800 spaces) • PT: Terminal Parking (6 levels/ 2400 spaces total) • PG: General Aviation Parking (1 level/200 spaces)	✔

Table 6.28 (Continued) – CAEPport case study airport features.

Point	x-Coordinate	y-Coordinate
ARP[7]	10000	10000
Ref1[7]	7821.54	8973.21
Ref2[7]	12665.46	10183.29
Receptor1	11620.26	11629.06
Receptor2	10537.72	11003.62
Receptor3	9455.192	10378.18
Receptor4	10727.5	13175.35
GridExtent1[8]	7000	7000
GridExtent2[8]	15000	15000

Table 6.29 – CAEPport case study reference point locations, receptor locations and grid extents.

[7] Reference points are included for completeness; these are not receptor locations.
[8] Grid extents are provided for the annual average NOx contour plot.

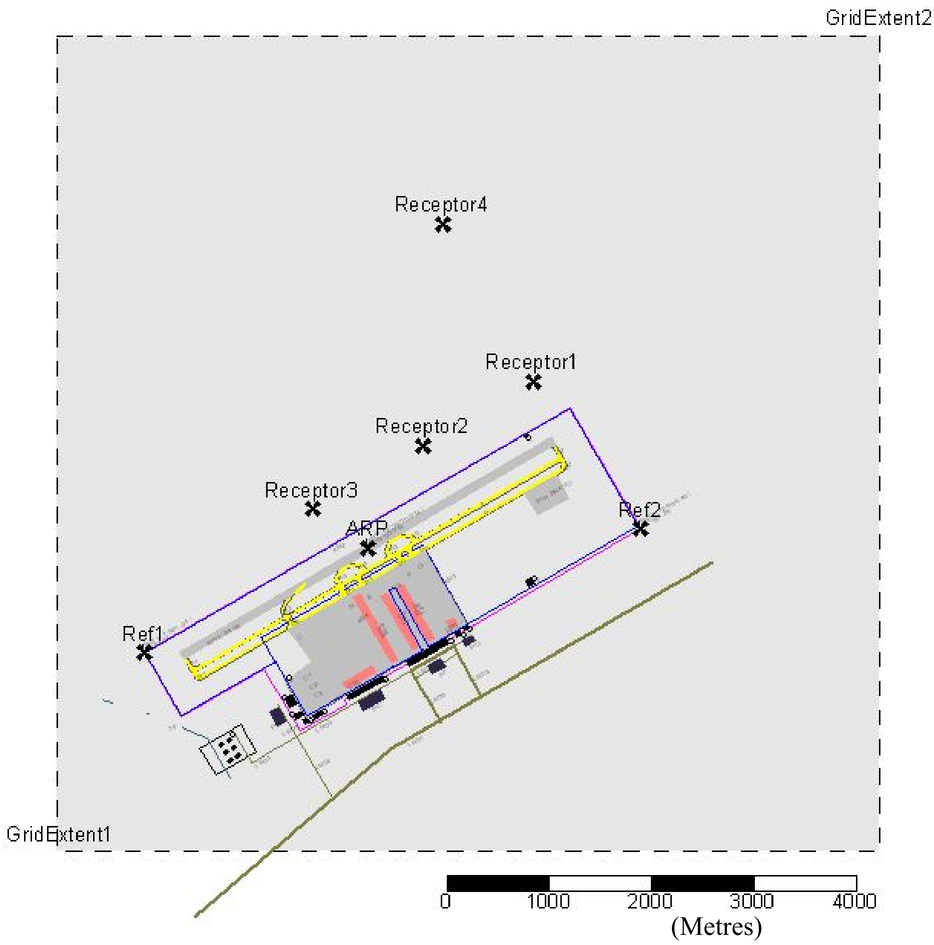


Figure 6.23 – Map of CAEPport case study receptor locations and grid extents.

Airport sources considered

The following emission sources were considered at CAEPport:

- Aircraft main engine emissions up to 3000ft:
  - Approach;
  - Landing;
  - Deceleration;
  - Taxi-in;
  - Taxi-out;
  - Take-off;
  - Initial climb;
  - Climb out;
- Aircraft APU emissions;
- Aircraft GSE emissions;
- Airport stationary sources:
  - Airport power plant;

  * Airport fuel farm;
- Urban emissions:
  * Landside roads;
  * Airport car parks;

Aircraft operations

CAEPport is a medium-sized airport with a high proportion of regional traffic and the hub of a national airline. There are 88,390 aircraft movements over the year 2004.

Table 6.30 shows the aircraft types operating at CAEPport. **Table 6.31** shows the aircraft use of the runways. **Table 6.32** shows the aircraft use of the stand types.

Aircraft Type	Aircraft code	Arrivals	Departures	Movements	Percentage of Movements
Embraer 145	E145	10271	10270	20541	23%
Aerospatiale ATR-72	AT72	4734	4723	9457	11%
Boeing 737-500	B735	4188	3999	8187	9%
Aerospatiale ATR-45	AT45	2838	2765	5603	6%
Boeing 737-400	B734	2820	2505	5325	6%
Embraer 170	E170	2671	2637	5308	6%
Airbus A319	A319	2362	2235	4597	5%
McDonnell Douglas MD11	MD11	2107	2109	4216	5%
Boeing 737-300	B733	1333	1371	2704	3%
Airbus A320	A320	1098	1243	2341	3%
Canadair Regional Jet RJ-200	CRJ2	1042	1042	2084	2%
Let 410	L410	983	984	1967	2%
Other - 71 different aircraft types		8122	7938	16060	18%

Table 6.30 – CAEPport case study annual aircraft operations.

Movement Type	Runway 06	Runway 24
Arrival	9%	91%
Departure	9%	91%

Table 6.31 – CAEPport case study distribution of aircraft operations by runway.

Stand Type	Stands	Percentage of Movements
Cargo	C01, C02, C03, C04, C05	1%
General	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10	10%
Remote	R01, R02, R03, R04, R05, R06, R07, R08, R09, R10, R11, R12	24%
Pier (West)	T10, T11, T12, T13, T14, T15, T16, T17, T18, T19	34%
Pier (East)	T20, T21, T22, T23, T24, T25, T26, T27, T28, T29	31%

Table 6.32 – CAEPport case study distribution of aircraft operations by stand type.

Other sources

APU and GSE operations were based on the aircraft operations declared.

The airport power plant has two oil burners each with 40 MW output. The total amount of fuel oil consumed is 3600 kg/hour, with each operating annually for 3000 hrs.

The airport fuel farm modelled consists of five kerosene tanks each with a diameter of 40 m and a height of 15 m. The tanks have sealed internal floating roofs and each contain an average of 18 million litres of kerosene.

Road traffic usage was provided for each of the landside airport roads for fleet components including cars, light duty vehicles and heavy duty vehicles.

Car park usage was provided for each of the airport car parks.

Meteorology

The meteorological data used was derived from actual data from a meteorological station near to London Heathrow airport in 1996. The meteorological data input consisted of:

- Day and time
- Wind direction
- Wind velocity
- Monin-Obukhov length

Figure 6.24 shows a wind rose of the meteorological data used in the study.

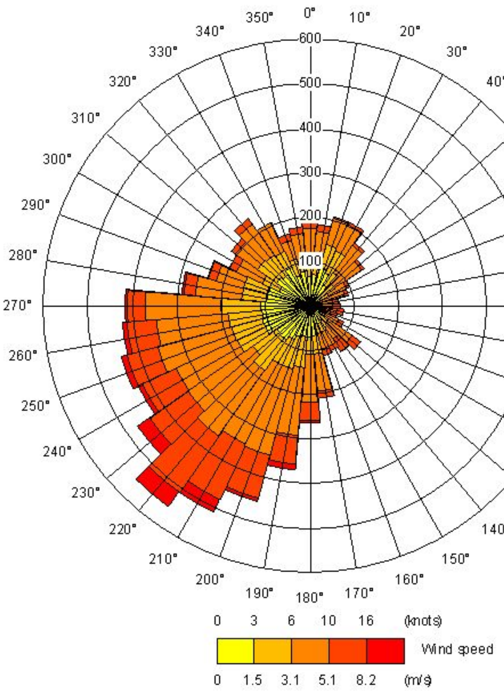


Figure 6.24 – CAEPport wind rose of meteorological data.

CAEPport Study Input into ADMS-Airport

This section describes the processes required to input the information provided for the CAEPport study into ADMS-Airport.

Summary of Emissions

Emissions from the various airport sources were calculated using a flight performance model for the aircraft sources, EMIT version 2.3 for APU, GSE, road traffic and car parking sources, while the emissions from the airport stationary sources were provided. **Table 6.33** gives the emissions at CAEPport from the sources specified as used by ADMS-Airport for dispersion modelling.

Source Group	CO (kg/yr)	VOC (kg/yr)	NO_x (kg/yr)	SO_x (kg/yr)	PM_{10} (kg/yr)
Aircraft Take-off	2,943	374	74,501	2,322	554
Aircraft Initial Climb	3,553	374	79,500	2,552	608
Aircraft Climb Out	3,602	261	58,691	2,230	479
Aircraft Approach	82,014	10,862	10,080	1,689	294
Aircraft Deceleration	1,865	225	21,733	999	225
Aircraft Taxi Out	138,117	15,323	23,273	4,384	1,376
Aircraft Taxi In	68,264	8,371	11,675	2,174	706
Aircraft APUs	11,060	838	5,975	-	-
GSE	6,148	1,538	10,590	-	797
Power Plant	7,200	362	34,800	70,200	1,440
Fuel Farm	-	112	-	-	-
Roads	32,392	5,263	19,753	228	803
Parking	20,740	8,393	1,363	8	40
Subtotals					
Aircraft	*300,359*	*35,789*	*279,453*	*16,351*	*4,243*
APUs	*11,060*	*838*	*5,975*	-	-
GSE	*6,148*	*1,538*	*10,590*	-	*797*
Stationary Sources	*7,200*	*474*	*34,800*	*70,200*	*1,440*
Roads & Parking	*53,132*	*13,655*	*21,116*	*236*	*843*
TOTAL	**377,899**	**52,294**	**351,933**	**86,787**	**7,323**

Table 6.33 – CAEPport case study emissions. Emissions from Aircraft Landing sources have been grouped with Aircraft Approach sources.

Aircraft modelling categories

Aircraft modelling categories (MCATs) are used to model aircraft with similar exhaust conditions together. This includes the exhaust locations relative to the aircraft, speed of the aircraft in a particular mode, engine exhaust temperature, velocity and diameter. The aircraft modelling categories used for CAEPport are given in **Table 6.34**. Note that aircraft in modelling category 0 are represented by volume sources not jet sources. The assignment of aircraft to the aircraft modelling categories is given in **Table 6.35**.

Aircraft Modelling Category	Description of Group	Aircraft/Engine Combination for Exhaust Conditions
0	• Piston aircraft • Turboprop aircraft • Business jet aircraft	N/A
1	• Large jet aircraft • Aircraft with 4 wing-mounted engines • Old engine technology	Boeing 747-200 CF6-50E2
2	• All size jet aircraft • Aircraft with 3 engines • All engine technologies	McDonnell Douglas MD11 PW4x62
3	• Medium and large jet aircraft • 2 wing-mounted engines • All engine technologies	Airbus A330 Trent 772
4	• Small and regional jet aircraft • 2 wing-mounted engines • Old and current engine technologies	Boeing 737-700 CFM56-3C1
5	• Small and regional jet aircraft • 2 fuselage-mounted engines • Old and current engine technologies	McDonnell Douglas MD87 JT8D-217C
6	• Large jet aircraft • 4 wing-mounted engines • Current engine technology	Boeing 747-700 RB211-524GH
7	• Regional jet aircraft • 4 wing-mounted engines • Current engine technology	Regional jet RJ85 LF507-1F, -1H
8	• Small jet aircraft • 2 wing-mounted engines • New engine technology	Boeing 737-800 Reconditioned Trent 500
9	• Regional jet aircraft • 2 fuselage-mounted engines • New engine technology	Embraer 145 AE3007A1

Table 6.34 – CAEPport case study aircraft modelling categories.

Aircraft Modelling Categories										
0		1	2	3	4	5	6	7	8	9
AN12	DHC7	B742	B721	A306	A318	CL60	A342	B462	B736	E145
AN24	E120	B743	B722	A30B	A319	CRJ1	A343	RJ1H	B737	E170
AN26	F2TH	B74S	MD11	A310	A320	CRJ2	B744	RJ70	B738	
AT43	F50	IL96	T154	A332	A321	CRJ7		RJ85	B739	
AT44	FA20			B762	B733	DC91				
AT45	FA50			B763	B734	DC93				
AT72	GLF3			B772	B735	F100				
B190	GLF4			B773	B752	F70				
BE35	L410			DC10	B753	MD81				
C525	P28A			IL76	YK40	MD82				
C550	PA34				YK42	MD83				
D328	SB20					MD87				
DH8C	SW4					MD90				
DH8D						T134				

Table 6.35 – CAEPport case study assignment of aircraft to aircraft modelling categories.

Modelling of emission sources in ADMS-Airport

Modelling of the emission sources in ADMS-Airport requires that the source type, location of the emission and temporal distribution of the emission be defined.

Table 6.36 shows the source types used for each of the sources at CAEPport. **Table 6.37** shows the basis for the spatial distribution of sources described in ADMS-Airport at CAEPport. **Table 6.38** shows the way in which the nature of the time-varying emissions was applied in ADMS-Airport.

CAEPport Source	ADMS-Airport Source Type		Parameters
Aircraft Take-off	MCAT 0: MCAT1-9:	Volume source Aircraft jet source	MCAT 0: height 1.75 m, depth 3.5 m MCAT 1-9: specified by MCAT
Aircraft Initial Climb	MCAT 0: MCAT1-9:	Volume source Aircraft jet source	MCAT 0: height and depth dependent on aircraft trajectory MCAT 1-9: specified by MCAT
Aircraft Climb Out	All MCATs:	Volume source	All MCATs: height and depth dependent on aircraft trajectory
Aircraft Approach	All MCATs:	Volume source	All MCATs: height and depth dependent on aircraft trajectory
Aircraft Landing	MCAT 0: MCAT1-9:	Volume source Aircraft jet source	MCAT 0: height and depth dependent on aircraft trajectory MCAT 1-9: specified by MCAT
Aircraft Deceleration	MCAT 0: MCAT1-9:	Volume source Aircraft jet source	MCAT 0: height 1.75 m, depth 3.5 m MCAT 1-9: specified by MCAT
Aircraft Taxi Out	All MCATs:	Volume source	All MCATs: height 1.75 m, depth 3.5 m
Aircraft Taxi In	All MCATs:	Volume source	All MCATs: height 1.75 m, depth 3.5 m
Aircraft APUs	Volume source		Height 6 m, depth 12 m
GSE	Volume source		Height 1 m, depth 2 m
Power Plant	Point source		Stack height 25 m, stack diameter 1.8 m, exhaust temperature 130°C, exhaust velocity 10 m/s
Fuel Farm	Area source		Height 10 m, velocity 0 m/s
Roads	Mobile: Stationary:	Road Area	Road width 20 m, speed as specified Height 10 m, velocity 0 m/s
Parking	Mobile: Stationary:	Road Area	Road width 20 m, speed as specified Height 10 m, velocity 0 m/s

Table 6.36 – CAEPport case study sources types

Source Group	**Spatial Distribution**
Aircraft Take-off	Generated based on straight departure trajectory, specific to aircraft type
Aircraft Initial Climb	Generated based on straight departure trajectory, specific to aircraft type
Aircraft Climb Out	Generated based on straight departure trajectory, specific to aircraft type
Aircraft Approach	Generated based on straight arrival trajectory, specific to aircraft type
Aircraft Landing	Generated based on straight arrival trajectory, specific to aircraft type
Aircraft Deceleration	Generated based on straight arrival trajectory, specific to aircraft type
Aircraft Taxi Out	Generated based on runway and stand used
Aircraft Taxi In	Generated based on runway and stand used
Aircraft APUs	Located at the 47 stands
GSE	Located at the 47 stands
Power Plant	At location given
Fuel Farm	At location given
Roads	At locations given
Parking	At locations given

Table 6.37 – CAEPport case study spatial distribution of emissions.

Source Group	Time-Varying Emission	Temporal Distribution
Aircraft Take-off	Hourly profile	88 HFC profiles based on aircraft type and aircraft departure runway
Aircraft Initial Climb	Hourly profile	2 HFC profiles based on aircraft departure runway
Aircraft Climb Out	Hourly profile	2 HFC profiles based on aircraft departure runway
Aircraft Approach	Hourly profile	2 HFC profiles based on aircraft arrival runway
Aircraft Landing	Hourly profile	2 HFC profiles based on aircraft arrival runway
Aircraft Deceleration	Hourly profile	2 HFC profiles based on aircraft arrival runway
Aircraft Taxi Out	Hourly profile	1 HFC profile based on all taxiing on departure
Aircraft Taxi In	Hourly profile	1 HFC profile based on all taxiing on arrival
Aircraft APUs	Hourly profile	46 HFC profiles based on aircraft arrival/departure stand
GSE	Hourly profile	46 HFC profiles based on aircraft arrival/departure stand
Power Plant	Constant emission	N/A
Fuel Farm	Constant emission	N/A
Roads	Hourly profile	1 HFC profile based on number of aircraft movements
Parking	Hourly profile	

Table 6.38 – CAEPport case study temporal distribution of emissions.

Source-oriented gridding

To produce detailed contour plots ADMS-Airport used regular grids and source-oriented grid points. A regular outer grid was applied over the whole area with a receptor point every 163 m. A regular inner grid was applied close to the airport with a receptor point every 83 m. To improve the resolution around aircraft and road sources irregular source-oriented grid points were applied along the runway, main taxi routes and roads. **Figure 6.25** shows the distribution of receptor points used to generate contour plots in ADMS-Airport.

Figure 6.26 shows the use of source-oriented grid points around aircraft sources in greater detail.

Figure 6.27 shows the use of source-oriented grid points around road sources in greater detail.

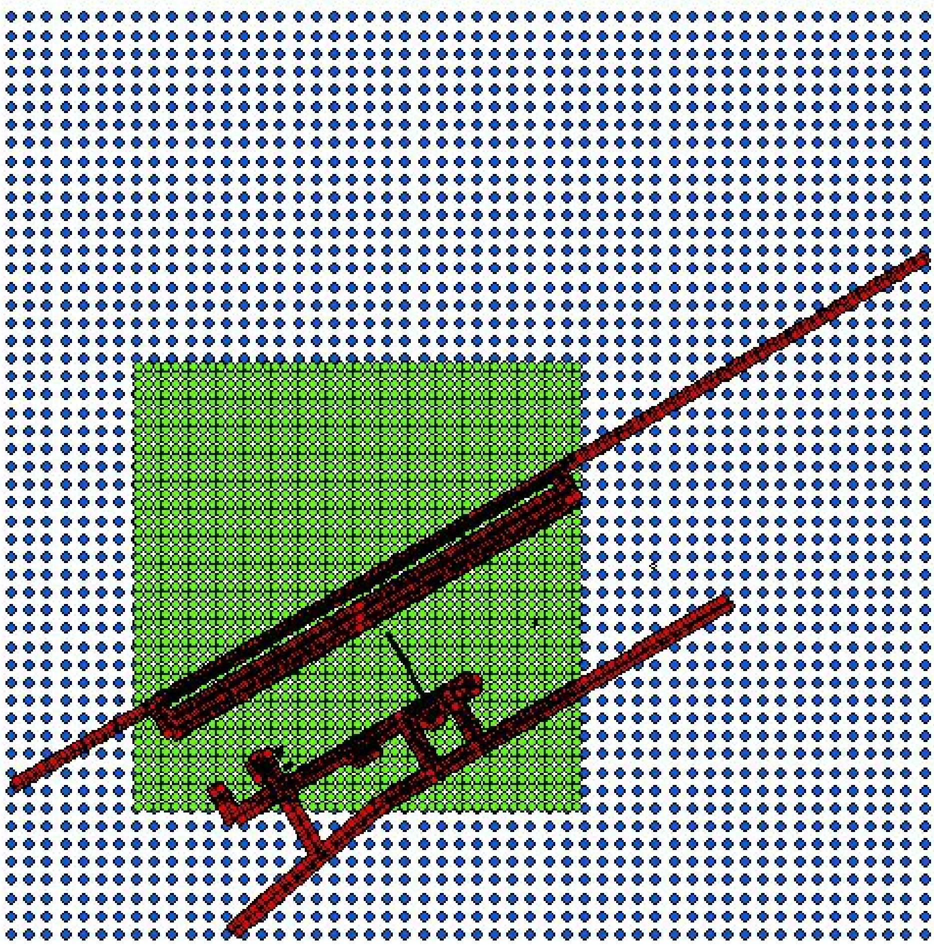


Figure 6.25 – CAEPport case study receptor locations for generation of contour plots
Outer grid point, Inner grid point, Source-oriented grid point

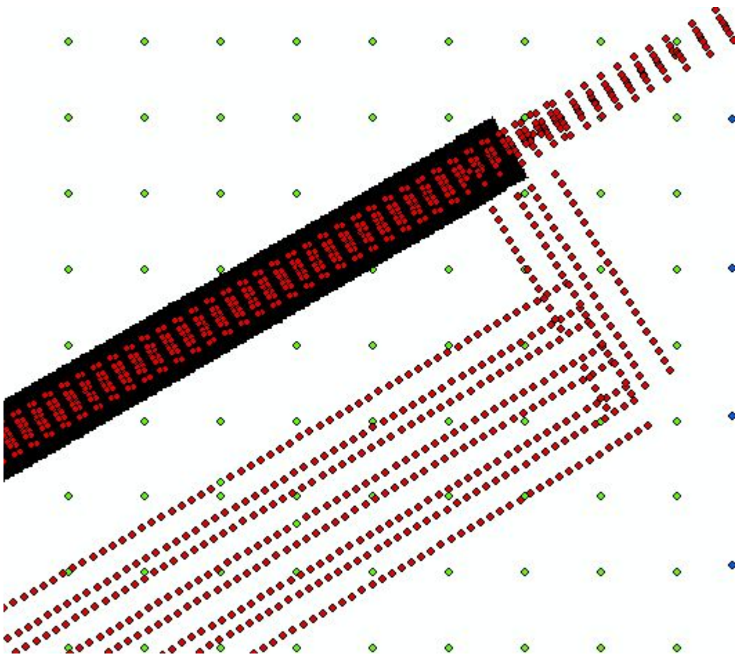


Figure 6.26 – CAEPport case study receptor locations for generation of contour plots – close up on aircraft runway and aircraft taxiing sources
Outer grid point, Inner grid point, Source-oriented grid point

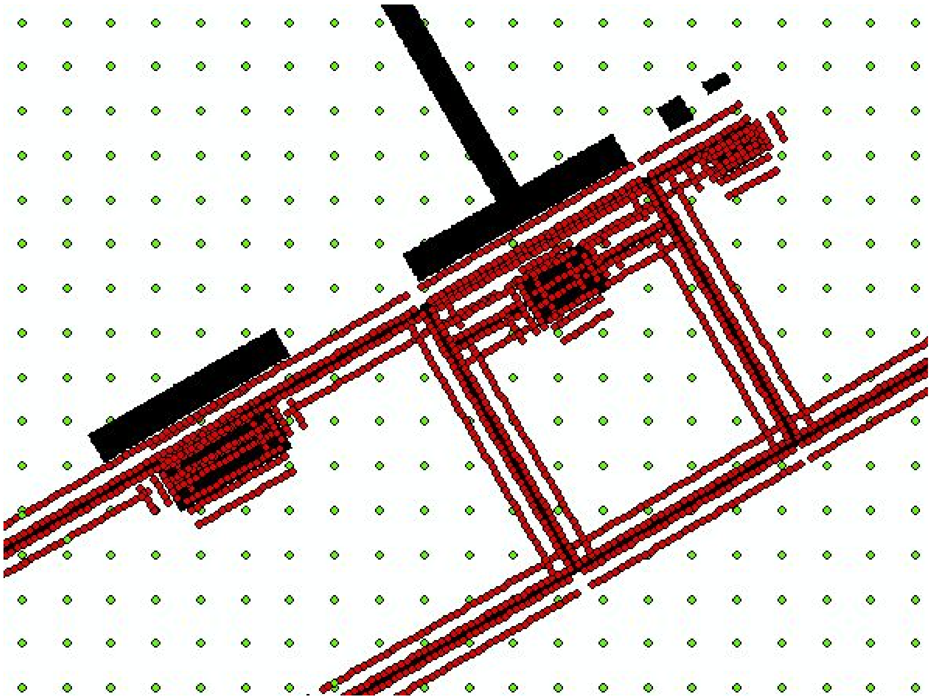


Figure 6.27 – CAEPport case study receptor locations for generation of contour plots – close up on road sources Outer grid point, Inner grid point, Source-oriented grid point

Modelling source groups separately

The airport was also assessed for source apportionment of different airport sources:

- Aircraft sources;
- Gate sources;
- Airport stationary sources; and
- Road traffic sources.

This was achieved by running ADMS-Airport for the sources appropriate for the different source groups separately.

View inputs in ADMS Mapper

Figures 6.28 and **6.29** show the inputs to ADMS-Airport in the ADMS Mapper for the CAEPport study.

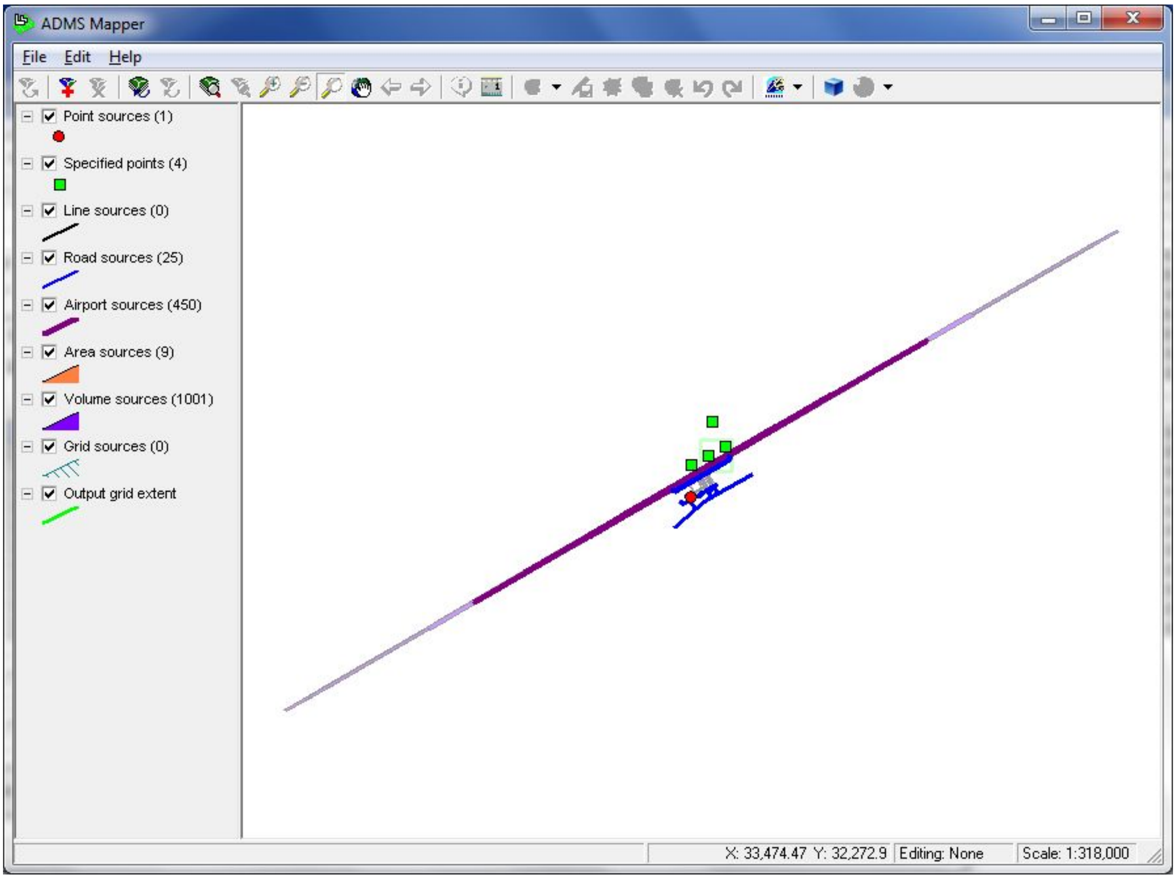


Figure 6.28 – CAEPport case study ADMS-Airport inputs.

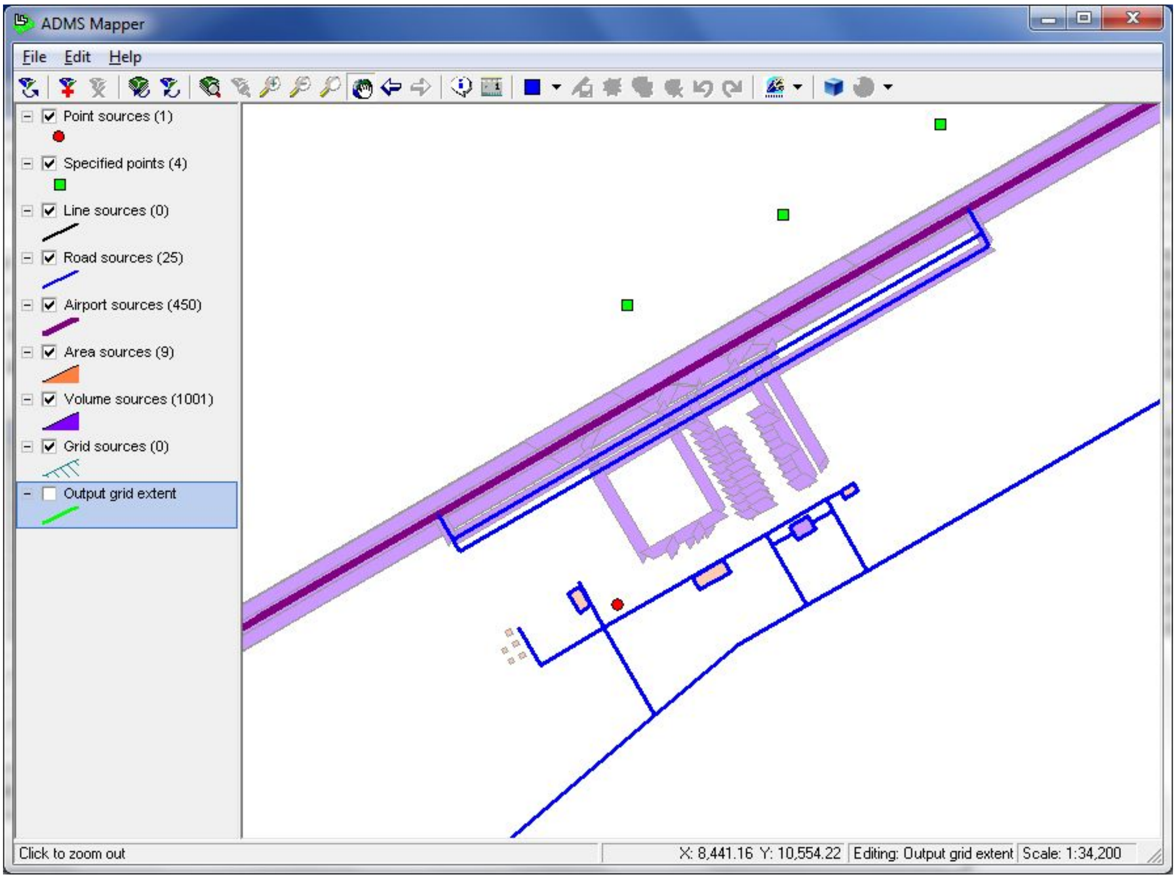


Figure 6.29 – CAEPport case study ADMS-Airport inputs – close up.

ADMS-Airport set-up

A basic airport set-up was defined, including Monin-Obukhov length, roughness, source types, met, background, grids (different resolutions and source-oriented points) and output.

Set-up

The basic set-up parameters used were as described in **Table 6.39.**

ADMS-Airport Set-up Parameter	**Value**
Surface roughness (m)	0.3
Latitude (º)	49.917
Minimum Monin-Obukhov length (m)	20

Table 6.39 – CAEPport case study basic set-up parameters.

Sources

The airport sources were defined in the groups shown in **Table 6.40**. This table also indicates whether the source details were defined in the *.air* file or imported via EMIT.

CAEPport Source	Input Via EMIT	Input Via AIR File
Aircraft Take-off	✔	✔
Aircraft Initial Climb	✔	✕
Aircraft Climb Out	✔	✕
Aircraft Approach	✔	✕
Aircraft Deceleration	✔	✔
Aircraft Taxi Out	✔	✕
Aircraft Taxi In	✔	✕
Aircraft APUs	✔	✕
GSE	✔	✕
Power Plant	✔	✕
Fuel Farm	✔	✕
Roads	✔	✕
Parking	✔	✕

Table 6.40 – CAEPport case study sources types.

Meteorology

The meteorological data file was as provided.

The hourly sequential meteorological data provided was selected with a recorded wind height of 10 m and wind sector size 10°. The meteorological data was defined as representative of the source site.

Background

Background values were set to zero for all pollutants.

Grids

Five versions of the model were run, all with the source-oriented grid option and receptors specified. The runs included a coarse grid over the entire extent of the airport analysis area and a fine grid over the airport facilities, refer to **Table 6.41** and **Figure 6.25** for details.

Run	Minimum (m)		Maximum (m)		Number of Points		Grid Resolution (m)	
	X	Y	X	Y	X	Y	X	Y
Outer grid	7000	7000	15000	15000	50	50	163	163
Inner grid, SW	8000	8000	10000	10000	25	25	83	83
Inner grid, NW	8000	10000	10000	12000	25	25	83	83
Inner grid, SE	10000	8000	12000	10000	25	25	83	83
Inner grid, NE	10000	10000	12000	12000	25	25	83	83

Table 6.41 – CAEPport case study grids.

Output

An output of long-term averaged NO_x results was selected.

Runs

To improve the time taken to run the study the airport area was split into five different grids. In total there were five runs to process the dispersion. The runs were performed on five machines and took several days to complete. The results of these runs were then post-processed.

This type of grid resolution is suitable for an isolated airport. Further grid detail may be required in areas other than the airport if the airport is in an urban environment.

Results

Annual mean and 95th percentile NO_x concentrations at receptor locations are provided in **Table 6.42** for all airport sources.

Annual mean NO_x concentrations at receptor locations are provided in **Table 6.43** for aircraft, gate, road traffic and stationary sources separately.

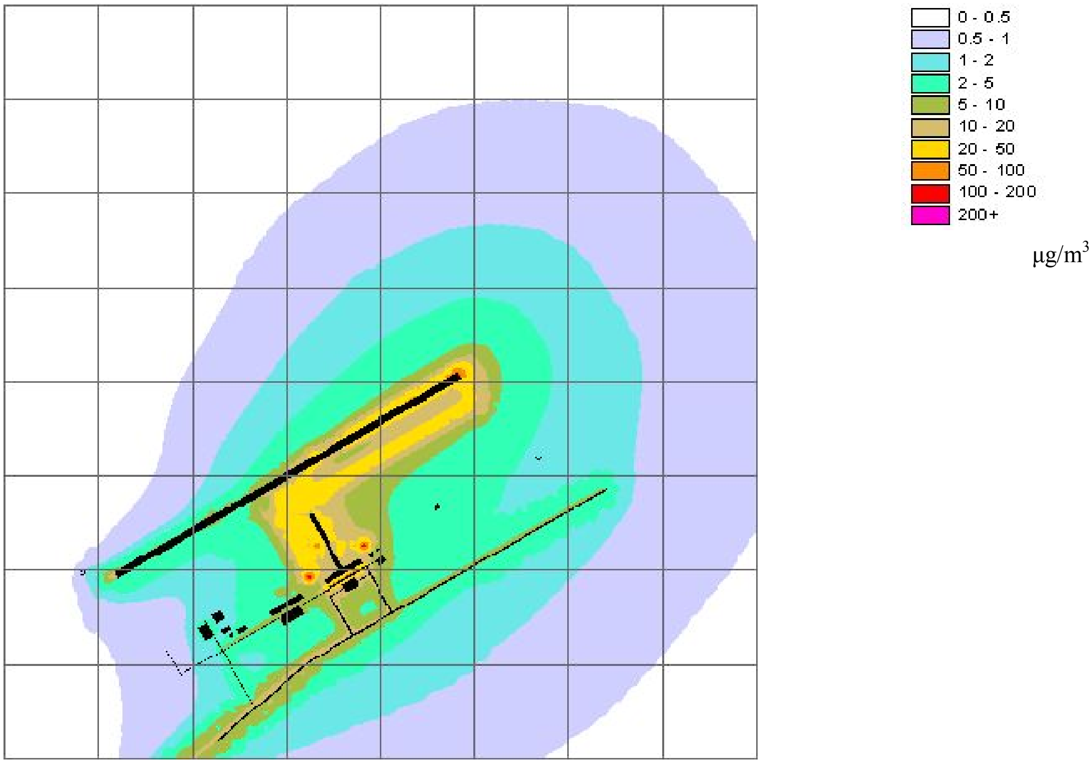
Receptor	Annual Hourly Mean ($\mu g/m^3$)	95th Percentile ($\mu g/m^3$)
R1	2.39	11.92
R2	2.06	10.39
R3	1.13	5.05
R4	0.55	3.15

Table 6.42 – CAEPport case study concentrations of NO_x at receptor locations for all source groups.

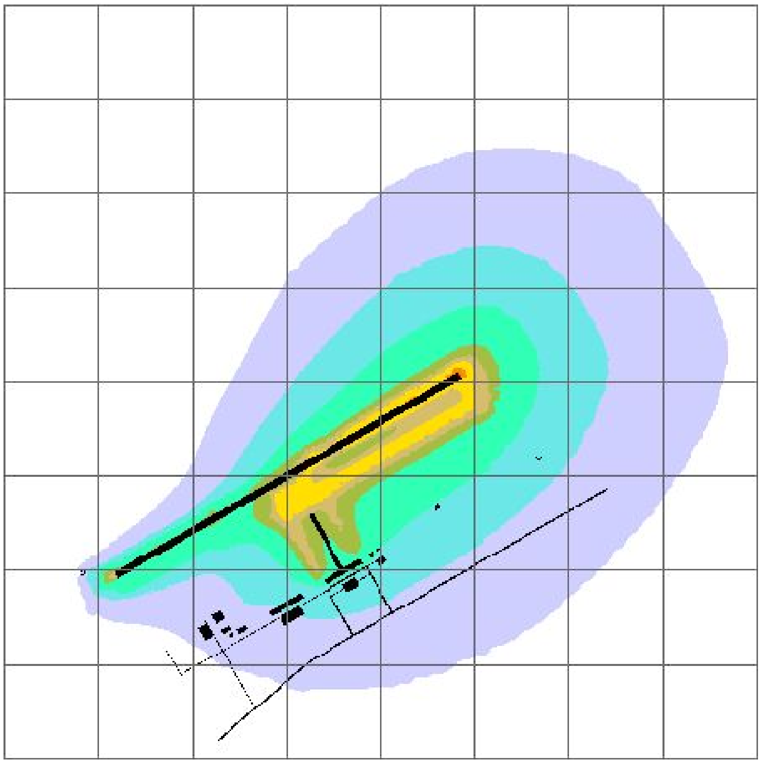
Receptor	Aircraft		GSE & APU		Road Traffic		Stationary Sources	
	($\mu g/m^3$)	%	($\mu g/m^3$)	%	($\mu g/m^3$)	%	($\mu g/m^3$)	%
R1	2.106	88.0%	0.129	5.4%	0.097	4.1%	0.060	2.5%
R2	1.637	79.6%	0.221	10.8%	0.121	5.9%	0.077	3.7%
R3	0.769	68.1%	0.184	16.3%	0.100	8.8%	0.077	6.8%
R4	0.407	74.4%	0.054	9.8%	0.046	8.4%	0.040	7.3%

Table 6.43 – CAEPport case study annual mean concentrations of NO_x at receptor locations for source groups.

Figure 6.30 shows contours of the annual mean NO_x concentration for all airport sources and annual mean NO_x concentration for aircraft sources. An annual average NO_x concentration contour is provided in **Figure 6.31** for aircraft, GSE & APU, road traffic and stationary sources separately. A regular grid is overlaid on the concentrations for reference.



(a)



(b)

Figure 6.30 – CAEPport NO_x contours (in µg/m^3) – (a) All Sources annual hourly mean, (b) Aircraft Sources annual hourly mean.

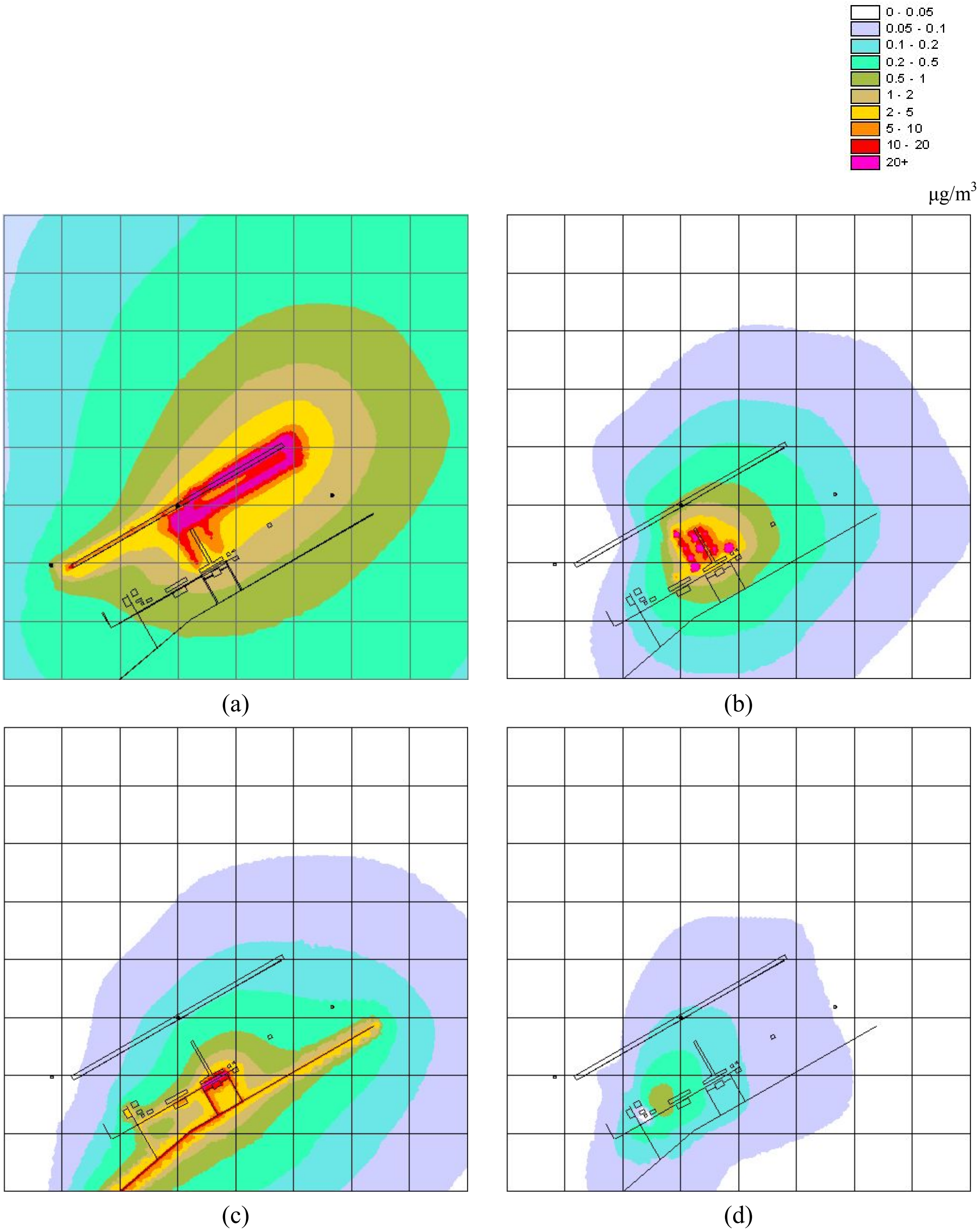


Figure 6.31 – CAEPport case study annual mean NO_x concentration contours (µg/m^3) for (a) aircraft sources, (b) APU & GSE sources, (c) road traffic sources and (d) stationary sources.

SECTION 7 Technical Summary

7.1 AIR FILE sources

Air File sources describe aircraft emissions as moving jet sources. The **Air File** sources are categorised according to the aircraft engine exhaust conditions.

The **air file categories** are described in the **top of the air file**; this section describes the categories in terms of aircraft and engine type, the engine exhaust conditions, an emission curve ID and engine positions. The **bottom of the air file** describes emission sources with reference to an **air file category**, the geometric location of the emissions, an emission time (only required if an emission curve is used for a take-off source via the *.sec* file), the number of jets into which to split the source and the amounts of each pollutant emitted. A default set of **air file categories** is given in Section 7.1.2.

Non-constant emission of pollutants can be represented using emission curves, referred to in the **Air File**.

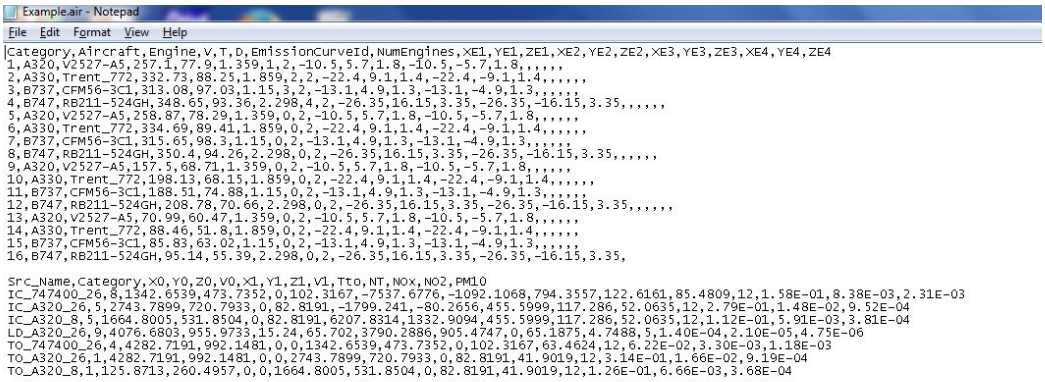
7.1.1 AIR FILE Format

The *.air* file is a *comma-separated* file, which contains details of modelled Air File sources. The file has two parts; the top half identifies a modelling category for the sources based on engine positions and operating parameters, and the bottom half details the modelled sources. An example **Air File** is shown in **Figure 7.1**. **Tables 7.1** and **7.3** show the column headings of the top and bottom parts of the **Air File** respectively.

The **air file categories** are described in the **top of the air file**; this section describes the categories in terms of aircraft and engine type (for labelling purposes), the engine exhaust conditions (velocity, temperature and engine diameter), an emission curve ID (used to identify use of a speed curve where non-constant acceleration is required for **Air File** take-off sources using the *.sec* file) and position of the engines.

There is no limit on the overall number of categories in the AIR FILE. The number of take-off categories is limited to 20.

Model runs using more categories take longer to run than runs using fewer categories.



Example.air - Notepad

File Edit Format View Help

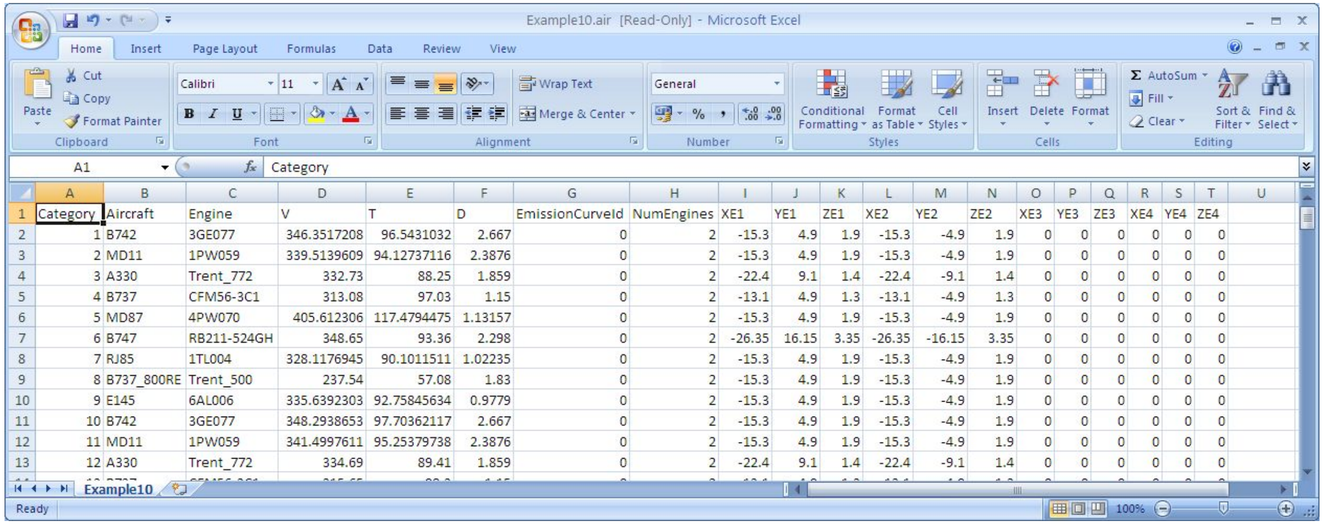
```
Category,Aircraft,Engine,V,T,D,EmissionCurveId,NumEngines,XE1,YE1,ZE1,XE2,YE2,ZE2,XE3,YE3,ZE3,XE4,YE4,ZE4
1,A320,V2527-A5,257.1,77.9,1.359,1,2,-10.5,5.7,1.8,-10.5,-5.7,1.8,,,,,,
2,A330,Trent_772,332.73,88.25,1.859,2,2,-22.4,9.1,1.4,-22.4,-9.1,1.4,,,,,,
3,B737,CFM56-3C1,313.08,97.03,1.15,3,2,-13.1,4.9,1.3,-13.1,-4.9,1.3,,,,,,
4,B747,RB211-524GH,348.65,93.36,2.298,4,2,-26.35,16.15,3.35,-26.35,-16.15,3.35,,,,,,
5,A320,V2527-A5,258.87,78.29,1.359,0,2,-10.5,5.7,1.8,-10.5,-5.7,1.8,,,,,,
6,A330,Trent_772,334.69,89.41,1.859,0,2,-22.4,9.1,1.4,-22.4,-9.1,1.4,,,,,,
7,B737,CFM56-3C1,315.65,98.3,1.15,0,2,-13.1,4.9,1.3,-13.1,-4.9,1.3,,,,,,
8,B747,RB211-524GH,350.4,94.26,2.298,0,2,-26.35,16.15,3.35,-26.35,-16.15,3.35,,,,,,
9,A320,V2527-A5,157.5,68.71,1.359,0,2,-10.5,5.7,1.8,-10.5,-5.7,1.8,,,,,,
10,A330,Trent_772,198.13,68.15,1.859,0,2,-22.4,9.1,1.4,-22.4,-9.1,1.4,,,,,,
11,B737,CFM56-3C1,188.51,74.88,1.15,0,2,-13.1,4.9,1.3,-13.1,-4.9,1.3,,,,,,
12,B747,RB211-524GH,208.78,70.66,2.298,0,2,-26.35,16.15,3.35,-26.35,-16.15,3.35,,,,,,
13,A320,V2527-A5,70.99,60.47,1.359,0,2,-10.5,5.7,1.8,-10.5,-5.7,1.8,,,,,,
14,A330,Trent_772,88.46,51.8,1.859,0,2,-22.4,9.1,1.4,-22.4,-9.1,1.4,,,,,,
15,B737,CFM56-3C1,85.83,63.02,1.15,0,2,-13.1,4.9,1.3,-13.1,-4.9,1.3,,,,,,
16,B747,RB211-524GH,95.14,55.39,2.298,0,2,-26.35,16.15,3.35,-26.35,-16.15,3.35,

Src_Name,Category,X0,Y0,Z0,V0,X1,Y1,Z1,V1,Tto,NT,NOx,NO2,PM10
IC_747400_26,8,1342.6539,473.7352,0,102.3167,-7537.6776,-1092.1068,794.3557,122.6161,85.4809,12,1.58E-01,8.38E-03,2.31E-03
IC_A320_26,5,2743.7899,720.7933,0,82.8191,-1799.241,-80.2656,455.5999,117.286,52.0635,12,2.79E-01,1.48E-02,9.52E-04
IC_A320_8,5,1664.8005,531.8504,0,82.8191,6207.8314,1332.9094,455.5999,117.286,52.0635,12,1.12E-01,5.91E-03,3.81E-04
LD_A320_26,9,4076.6803,955.9733,15.24,65.702,3790.2886,905.4747,0,65.1875,4.7488,5,1.40E-04,2.10E-05,4.75E-06
TO_747400_26,4,4282.7191,992.1481,0,0,1342.6539,473.7352,0,102.3167,63.4624,12,6.22E-02,3.30E-03,1.18E-03
TO_A320_26,1,4282.7191,992.1481,0,0,2743.7899,720.7933,0,82.8191,41.9019,12,3.14E-01,1.66E-02,9.19E-04
TO_A320_8,1,125.8713,260.4957,0,0,1664.8005,531.8504,0,82.8191,41.9019,12,1.26E-01,6.66E-03,3.68E-04
```

Figure 7.1 – An example **Air File**

*The top of the **Air File***

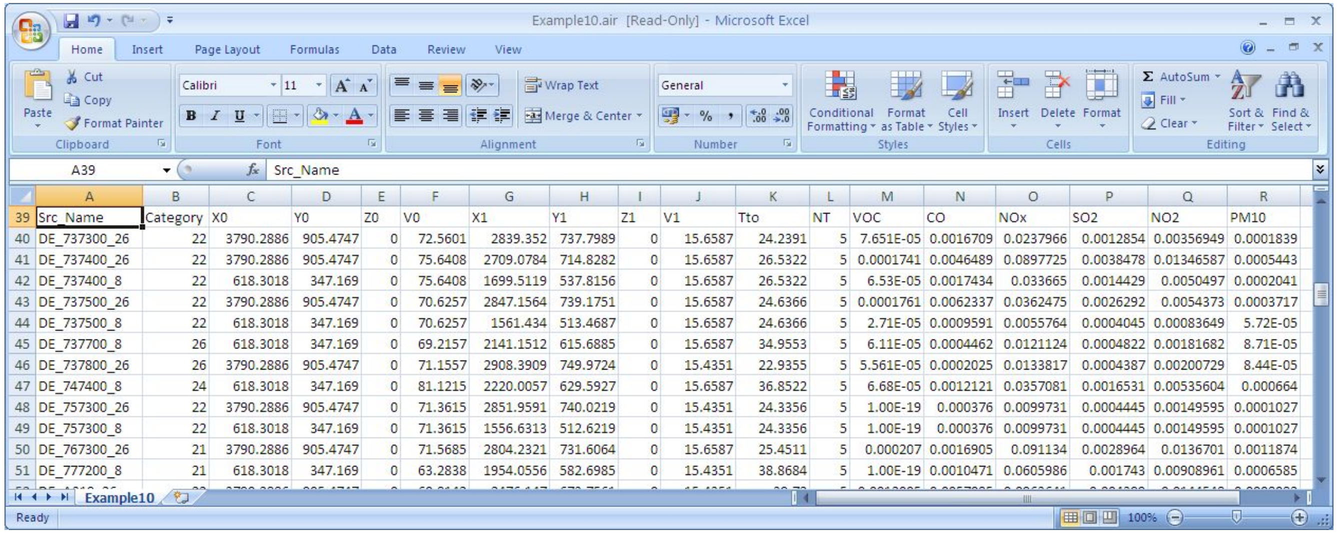
The top of the *.air* file is shown in more detail in **Figure 7.2**. The column headings are described in **Table 7.1**. This part of the file assigns a category number to different engines and their operating conditions. In the example there are four different airframe-engine types, each with four different operating conditions that in this example represent take-off roll, initial climb, landing and taxiing. When a *.sec* file is used, the *EmissionCurveID* column contains a non-zero value.

Information in the top of the **Air File** uses aircraft engine parameters to describe the buoyancy of the exhaust plume, the diameter of the aircraft engine exhaust and the location of the exhaust relative to the aircraft itself. The exhaust buoyancy is described in terms of the engine exhaust velocity and temperature.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Category	Aircraft	Engine	V	T	D	EmissionCurveId	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
2	1	B742	3GE077	346.3517208	96.5431032	2.667	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
3	2	MD11	1PW059	339.5139609	94.12737116	2.3876	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
4	3	A330	Trent_772	332.73	88.25	1.859	0	2	-22.4	9.1	1.4	-22.4	-9.1	1.4	0	0	0	0	0	0
5	4	B737	CFM56-3C1	313.08	97.03	1.15	0	2	-13.1	4.9	1.3	-13.1	-4.9	1.3	0	0	0	0	0	0
6	5	MD87	4PW070	405.612306	117.4794475	1.13157	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
7	6	B747	RB211-524GH	348.65	93.36	2.298	0	2	-26.35	16.15	3.35	-26.35	-16.15	3.35	0	0	0	0	0	0
8	7	RJ85	1TL004	328.1176945	90.1011511	1.02235	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
9	8	B737_800RE	Trent_500	237.54	57.08	1.83	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
10	9	E145	6AL006	335.6392303	92.75845634	0.9779	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
11	10	B742	3GE077	348.2938653	97.70362117	2.667	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
12	11	MD11	1PW059	341.4997611	95.25379738	2.3876	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9	0	0	0	0	0	0
13	12	A330	Trent_772	334.69	89.41	1.859	0	2	-22.4	9.1	1.4	-22.4	-9.1	1.4	0	0	0	0	0	0

Figure 7.2 – Top of an *.air* file opened in Microsoft Excel



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
39	Src_Name	Category	X0	Y0	Z0	V0	X1	Y1	Z1	V1	Tto	NT	VOC	CO	NOx	SO2	NO2	PM10
40	DE_737300_26	22	3790.2886	905.4747	0	72.5601	2839.352	737.7989	0	15.6587	24.2391	5	7.651E-05	0.0016709	0.0237966	0.0012854	0.00356949	0.0001839
41	DE_737400_26	22	3790.2886	905.4747	0	75.6408	2709.0784	714.8282	0	15.6587	26.5322	5	0.0001741	0.0046489	0.0897725	0.0038478	0.01346587	0.0005443
42	DE_737400_8	22	618.3018	347.169	0	75.6408	1699.5119	537.8156	0	15.6587	26.5322	5	6.53E-05	0.0017434	0.033665	0.0014429	0.0050497	0.0002041
43	DE_737500_26	22	3790.2886	905.4747	0	70.6257	2847.1564	739.1751	0	15.6587	24.6366	5	0.0001761	0.0062337	0.0362475	0.0026292	0.0054373	0.0003717
44	DE_737500_8	22	618.3018	347.169	0	70.6257	1561.434	513.4687	0	15.6587	24.6366	5	2.71E-05	0.0009591	0.0055764	0.0004045	0.00083649	5.72E-05
45	DE_737700_8	26	618.3018	347.169	0	69.2157	2141.1512	615.6885	0	15.6587	34.9553	5	6.11E-05	0.0004462	0.0121124	0.0004822	0.00181682	8.71E-05
46	DE_737800_26	26	3790.2886	905.4747	0	71.1557	2908.3909	749.9724	0	15.4351	22.9355	5	5.561E-05	0.0002025	0.0133817	0.0004387	0.00200729	8.44E-05
47	DE_747400_8	24	618.3018	347.169	0	81.1215	2220.0057	629.5927	0	15.6587	36.8522	5	6.68E-05	0.0012121	0.0357081	0.0016531	0.00535604	0.000664
48	DE_757300_26	22	3790.2886	905.4747	0	71.3615	2851.9591	740.0219	0	15.4351	24.3356	5	1.00E-19	0.000376	0.0099731	0.0004445	0.00149595	0.0001027
49	DE_757300_8	22	618.3018	347.169	0	71.3615	1556.6313	512.6219	0	15.4351	24.3356	5	1.00E-19	0.000376	0.0099731	0.0004445	0.00149595	0.0001027
50	DE_767300_26	21	3790.2886	905.4747	0	71.5685	2804.2321	731.6064	0	15.6587	25.4511	5	0.000207	0.0016905	0.091134	0.0028964	0.0136701	0.0011874
51	DE_777200_8	21	618.3018	347.169	0	63.2838	1954.0556	582.6985	0	15.4351	38.8684	5	1.00E-19	0.0010471	0.0605986	0.001743	0.00908961	0.0006585

Figure 7.3 – Bottom of an *.air* file opened in Microsoft Excel

Column heading	Data	Restrictions
Category	Category number	Must be sequential starting from 1
Aircraft	Aircraft name	
Engine	Engine name	
V	Exit velocity of the engine exhaust relative to the aircraft (m/s)	0 to 1000
T	Exit temperature of the engine exhaust (°C)	-10 to 5000
D	Engine diameter (m), effective diameter at exhaust exit	> 0
EmissionCurveID	Emission curve reference for *.sec* file (take off only)	0 for non-take off or no *.sec* file used Match to *.sec* file for take off
NumEngines	Number of engines modelled per aircraft	1 to 4
XE1	Horizontal distance (along aircraft) of engine 1, relative to the foremost point of the aircraft (m)	
YE1	Horizontal distance (across aircraft) of engine 1, relative to the centreline of the aircraft (m)	
ZE1	Height of engine 1 (m)	> 0
XE2	Horizontal distance (along aircraft) of engine 2, relative to the foremost point of the aircraft (m)	Blank if not required
YE2	Horizontal distance (across aircraft) of engine 2, relative to the centreline of the aircraft (m)	Blank if not required
ZE2	Height of engine 2 (m)	> 0, blank if not required
XE3	Horizontal distance (along aircraft) of engine 3, relative to the foremost point of the aircraft (m)	Blank if not required
YE3	Horizontal distance (across aircraft) of engine 3, relative to the centreline of the aircraft (m)	Blank if not required
ZE3	Height of engine 3 (m)	> 0, blank if not required
XE4	Horizontal distance (along aircraft) of engine 4, relative to the foremost point of the aircraft (m)	Blank if not required
YE4	Horizontal distance (across aircraft) of engine 4, relative to the centreline of the aircraft (m)	Blank if not required
ZE4	Height of engine 4 (m)	> 0, blank if not required

Table 7.1 – Column headings for top of *.air* file

*Each category described in the top of the **Air File** represents aircraft engine exhaust conditions and the location of the engines on the aircraft.*

Users may require several categories to describe aircraft exhaust conditions throughout all phases of flight. For example you may require a separate category for take-off, initial climb, approach, landing and taxiing.

*The bottom of the **Air File***

Information in the bottom of the **Air File** includes all the **Air File** sources to be modelled. Each **Air File** source describes exhaust conditions to be applied to the source (Category), development of the aircraft exhaust plume as the aircraft travels in the vicinity of the airport (X0, Y0, Z0, V0, X1, Y1, Z1 and V1), the time that the source is emitting where non-constant acceleration is required (Tto), the number of time steps to be used in the modelling of the source (NT) and the source emissions (*Pollutant names*).

***Air file** sources are assumed to have constant acceleration unless they refer to a category with an **emissions curve**.*

The bottom of the *.air* file is shown in more detail in **Figure 7.3**. The column headings are described in more detail in **Table 7.3**. Engines are modelled as moving jet sources in the *.air* file; therefore the bottom of the file is used to describe the speed and movement of the aircraft as well as the emission rates of pollutants. In the example *.air* file, take-off, initial climb and landing sources are shown.

The modelled sources in the *.air* file must be at least 1 m in length and either the start or end velocity of the sources must be non-zero. The value for NT specifies the number of jets used to model the source. The value of NT should be based on the length of the Air File source; the longer the length of the Air File source, the greater the value of NT required. The value of NT required also depends on the aircraft mode, i.e. take-off, initial climb. **Table 7.2** shows advisable maximum jet spacing for aircraft modes.

Aircraft Mode	**Maximum jet source spacing (m)**	**Example NT value (Source length 2000 m)**
Take-off	200	11
Initial climb	300	8
Climb out	700	4
Approach	700	4
Taxiing	400	6

Table 7.2 – Advisable maximum jet source spacing for **Air File** sources

NT must be an integer value.

*These NT values are of the order used for the study of Heathrow (**DfT 2006**). Where there are fewer aircraft sources you will need to use more jet sources to maintain good resolution in your contour plots.*

Each line in the bottom of the *.air* file lists a component of a modelled **Air File** source. Therefore if, for example, two different aircraft types share the same take off trajectory, the same *Src_Name* can be used, as long as the *Category* numbers are different. Although the aircraft take-off on the same runway they would be modelled using the efflux parameters for the different

categories from the top of the **Air File** and could have different take-off speeds and take-off roll times specified in the bottom of the **Air File**.

Each line in the bottom of the .air file must have a unique combination of Src_Name *and* Category *number. Up to 500 unique source names can be modelled with a standard licence.*

Column heading	Data	Restrictions
Src_Name	Source name	Limited to 20characters
Category	Category number	Match to top of the *.air* file
X0	X-coordinate of aircraft starting position (m)	-9,999,999 – 9,999,999
Y0	Y-coordinate of aircraft starting position (m)	-9,999,999 – 9,999,999
Z0	Starting height of the aircraft (m)	≥ 0
V0	Starting velocity of the aircraft (m/s)	≥ 0
X1	X-coordinate of aircraft finishing position (m)	-9,999,000 – 9,999,999
Y1	Y-coordinate of aircraft finishing position (m)	-9,999,000 – 9,999,999
Z1	Finishing height of the aircraft (m)	≥ 0
V1	Finishing velocity of the aircraft (m/s)	≥ 0
Tto	Time to take-off (s)	≥ 0, for take-offs only, else value ignored
NT	Number of jets modelled	$0 \leq \mathrm{NT} \leq \dfrac{400}{\text{Num Of Engines}}$
Pollutant names	Emissions rates for different pollutants (g/s)	≥ 0

Table 7.3 – Column headings for the bottom of the *.air* file.

The emission rate represents the total emission rate for that source/category combination, not a per engine emission rate. For example, when modelling one year using a normalised .hfc profile, as described in Section 7.4, then the emission rate should be the annual average emission rate for all aircraft movements represented by that source/category combination.

7.1.2 Default AIR FILE Categories

Default aircraft-engine exhaust conditions are provided in this section to be used in the top of the **Air File**. The default conditions provided are suitable for a large airport with a high proportion of large passenger aircraft. The 14 airframe-engine combinations considered are:

- Airbus A320 with International Aero Engines V2527-A5 engines;
- Airbus A330 with Rolls Royce Trent 772 engines;
- Airbus A340-300 with CFM International CFM56-5C4 engines;
- Airbus B737 with CFM International CFM56-3C1 engines;

- Boeing 747 with Rolls Royce RB211-524GH engines;
- Boeing 777 with Rolls Royce Trent 892 engines;
- Boeing 787-300 with General Electric GEnx engines;
- Airbus A340-600 with Rolls Royce Trent 556 engines;
- Airbus A350-800 with new Rolls Royce Trent 500 engines;
- Airbus B737-800RE with Rolls Royce Trent 500 engines;
- A new aircraft for 120 passengers with new CFM International engines;
- A new aircraft for 150 passengers with new CFM International engines;
- A new aircraft for 180 passengers with new CFM International engines; and
- A new aircraft for 450 passengers with new General Electric GE90 engines.

The default conditions provided in **Tables 7.4 to 7.7** are for aircraft modes take-off (100% thrust), initial climb (85% thrust), landing (30% thrust) and taxiing (7% thrust) respectively.

Category	Aircraft	Engine	V	T	D	EmissionCurveID	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
1	A320	V2527-A5	277.31	79.91	1.359	1	2	-10.5	5.7	1.8	-10.5	-5.7	1.8						
2	A330	Trent_772	361.50	94.91	1.859	2	2	-22.4	9.1	1.4	-22.4	-9.1	1.4						
3	A340_300	CFM56-5C4	331.00	85.82	1.97	3	2	-24.45	14.35	2.7	-24.45	-14.35	2.7						
4	B737	CFM56-3C1	339.66	102.63	1.15	4	2	-13.1	4.9	1.3	-13.1	-4.9	1.3						
5	B747	RB211-524GH	379.09	98.39	2.298	5	2	-26.35	16.15	3.35	-26.35	-16.15	3.35						
6	B777	Trent_892	358.36	89.36	2.525	6	2	-21.2	9.9	2.4	-21.2	-9.9	2.4						
7	B787_3	GENx	224.56	55.21	2.364	7	2	-19.3	8.3	2.2	-19.3	-8.3	2.2						
8	A340_600	Trent_556	268.42	70.35	2.934	8	2	-26.3	15.35	2.95	-26.3	-15.35	2.95						
9	A350_800	T500	273.77	58.05	2.292	9	2	-21.4	9.6	2.6	-21.4	-9.6	2.6						
10	B737_800RE	Trent_500	255.94	59.46	1.83	10	2	-15.3	4.9	1.9	-15.3	-4.9	1.9						
11	New120s	CFM56_X	196.20	54.53	1.838	11	2	-12.9	5.4	1.5	-12.9	-5.4	1.5						
12	New150s	CFM56_X	237.24	57.78	1.662	12	2	-17.6	7.5	2	-17.6	-7.5	2						
13	New180s	CFM56_X	271.66	71.69	1.601	13	2	-16.6	7.2	1.9	-16.6	-7.2	1.9						
14	New450s	GE90-130B	285.14	58.76	2.991	14	2	-23.1	11.4	3	-23.1	-11.4	3						

Table 7.4 – Default top of the **Air File** categories 1 – 14 for take-off

Category	Aircraft	Engine	V	T	D	EmissionCurveID	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
15	A320	V2527-A5	258.87	78.29	1.359	0	2	-10.5	5.7	1.8	-10.5	-5.7	1.8						
16	A330	Trent_772	334.69	89.41	1.859	0	2	-22.4	9.1	1.4	-22.4	-9.1	1.4						
17	A340_300	CFM56-5C4	308.63	82.93	1.97	0	2	-24.45	14.35	2.7	-24.45	-14.35	2.7						
18	B737	CFM56-3C1	315.65	98.3	1.15	0	2	-13.1	4.9	1.3	-13.1	-4.9	1.3						
19	B747	RB211-524GH	350.4	94.26	2.298	0	2	-26.35	16.15	3.35	-26.35	-16.15	3.35						
20	B777	Trent_892	332.08	84.55	2.525	0	2	-21.2	9.9	2.4	-21.2	-9.9	2.4						
21	B787_3	GENx	212.28	54.16	2.364	0	2	-19.3	8.3	2.2	-19.3	-8.3	2.2						
22	A340_600	Trent_556	251.23	68.67	2.934	0	2	-26.3	15.35	2.95	-26.3	-15.35	2.95						
23	A350_800	T500	256.08	55.99	2.292	0	2	-21.4	9.6	2.6	-21.4	-9.6	2.6						
24	B737_800RE	Trent_500	239.9	57.84	1.83	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9						
25	New120s	CFM56_X	185.17	53.35	1.838	0	2	-12.9	5.4	1.5	-12.9	-5.4	1.5						
26	New150s	CFM56_X	223.73	56.14	1.662	0	2	-17.6	7.5	2	-17.6	-7.5	2						
27	New180s	CFM56_X	254.79	68.55	1.601	0	2	-16.6	7.2	1.9	-16.6	-7.2	1.9						
28	New450s	GE90-130B	266.12	57.44	2.991	0	2	-23.1	11.4	3	-23.1	-11.4	3						

Table 7.5 – Default top of the **Air File** categories 15 – 28 for initial climb

Category	Aircraft	Engine	V	T	D	EmissionCurveID	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
29	A320	V2527-A5	157.5	68.71	1.359	0	2	-10.5	5.7	1.8	-10.5	-5.7	1.8						
30	A330	Trent_772	198.13	68.15	1.859	0	2	-22.4	9.1	1.4	-22.4	-9.1	1.4						
31	A340_300	CFM56-5C4	185.67	66.42	1.97	0	2	-24.45	14.35	2.7	-24.45	-14.35	2.7						
32	B737	CFM56-3C1	188.51	74.88	1.15	0	2	-13.1	4.9	1.3	-13.1	-4.9	1.3						
33	B747	RB211-524GH	208.78	70.66	2.298	0	2	-26.35	16.15	3.35	-26.35	-16.15	3.35						
34	B777	Trent_892	196.75	65.22	2.525	0	2	-21.2	9.9	2.4	-21.2	-9.9	2.4						
35	B787_3	GENx	131.46	47.93	2.364	0	2	-19.3	8.3	2.2	-19.3	-8.3	2.2						
36	A340_600	Trent_556	153.23	58.44	2.934	0	2	-26.3	15.35	2.95	-26.3	-15.35	2.95						
37	A350_800	T500	156.28	44.65	2.292	0	2	-21.4	9.6	2.6	-21.4	-9.6	2.6						
38	B737_800RE	Trent_500	146.11	47.94	1.83	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9						
39	New120s	CFM56_X	114.71	47.23	1.838	0	2	-12.9	5.4	1.5	-12.9	-5.4	1.5						
40	New150s	CFM56_X	139.32	47.57	1.662	0	2	-17.6	7.5	2	-17.6	-7.5	2						
41	New180s	CFM56_X	155.36	51.97	1.601	0	2	-16.6	7.2	1.9	-16.6	-7.2	1.9						
42	New450s	GE90-130B	162.01	47.58	2.991	0	2	-23.1	11.4	3	-23.1	-11.4	3						

Table 7.6 – Default top of the **Air File** categories 29 – 42 for landing

Category	Aircraft	Engine	V	T	D	EmissionCurveID	NumEngines	XE1	YE1	ZE1	XE2	YE2	ZE2	XE3	YE3	ZE3	XE4	YE4	ZE4
43	A320	V2527-A5	70.99	60.47	1.359	0	2	-10.5	5.7	1.8	-10.5	-5.7	1.8						
44	A330	Trent_772	88.46	51.8	1.859	0	2	-22.4	9.1	1.4	-22.4	-9.1	1.4						
45	A340_300	CFM56-5C4	84.71	55.58	1.97	0	2	-24.45	14.35	2.7	-24.45	-14.35	2.7						
46	B737	CFM56-3C1	85.83	63.02	1.15	0	2	-13.1	4.9	1.3	-13.1	-4.9	1.3						
47	B747	RB211-524GH	95.14	55.39	2.298	0	2	-26.35	16.15	3.35	-26.35	-16.15	3.35						
48	B777	Trent_892	87.52	48.44	2.525	0	2	-21.2	9.9	2.4	-21.2	-9.9	2.4						
49	B787_3	GENx	59.63	35.93	2.364	0	2	-19.3	8.3	2.2	-19.3	-8.3	2.2						
50	A340_600	Trent_556	69.46	48.9	2.934	0	2	-26.3	15.35	2.95	-26.3	-15.35	2.95						
51	A350_800	T500	71.32	37.31	2.292	0	2	-21.4	9.6	2.6	-21.4	-9.6	2.6						
52	B737_800RE	Trent_500	65.12	38.7	1.83	0	2	-15.3	4.9	1.9	-15.3	-4.9	1.9						
53	New120s	CFM56_X	50.85	39.29	1.838	0	2	-12.9	5.4	1.5	-12.9	-5.4	1.5						
54	New150s	CFM56_X	63.58	40.32	1.662	0	2	-17.6	7.5	2	-17.6	-7.5	2						
55	New180s	CFM56_X	70.52	41.96	1.601	0	2	-16.6	7.2	1.9	-16.6	-7.2	1.9						
56	New450s	GE90-130B	73.07	37.66	2.991	0	2	-23.1	11.4	3	-23.1	-11.4	3						

Table 7.7 – Default top of the **Air File** categories 43 – 56 for taxiing

7.1.3 Creating your own AIR FILE categories

To improve the accuracy and efficiency of your model you may wish to create your own *.air* file categories specific to your modelling situation. This will allow you to incorporate the mix of aircraft operating at your airport and incorporate specific aircraft engine data that may be available to you.

Aircraft engine exhaust velocity and temperature data are not freely available. However, a generic relationship between jet engine bypass ratio (BPR) and engine exhaust velocity and temperature has been developed by CERC for use in ADMS-Airport. Engine BPRs are readily available in the ICAO emissions databank for jet engines larger than 26.7 kN thrust.

Details of these generic relationships are available in Section 8.4.

By creating your own *.air* file categories you can reflect the majority of aircraft operating at your airport and potentially reduce the number of categories required, hence improving run time. You can also better reflect the aircraft operating at your airport by choosing engine exhaust conditions that match your aircraft fleet, using either estimated exhaust conditions or engine manufacturer's data if it is available.

7.2 Emission Curve File

The emission curve file describes the development of speed and emissions of **Air File** sources with non-constant acceleration. The emission curve file is a comma-separated file which must be located in the same directory as the *.upl*, with the same file name as the *.upl* and with the file extension *.sec*.

7.2.1 Emission Curve File Format

An example of a *.sec* file is shown in **Figure 7.4**. In the file, one set of parameters is entered to describe the speed curves for all aircraft types, whereas parameters for multiple aircraft-specific emissions curves can be entered.

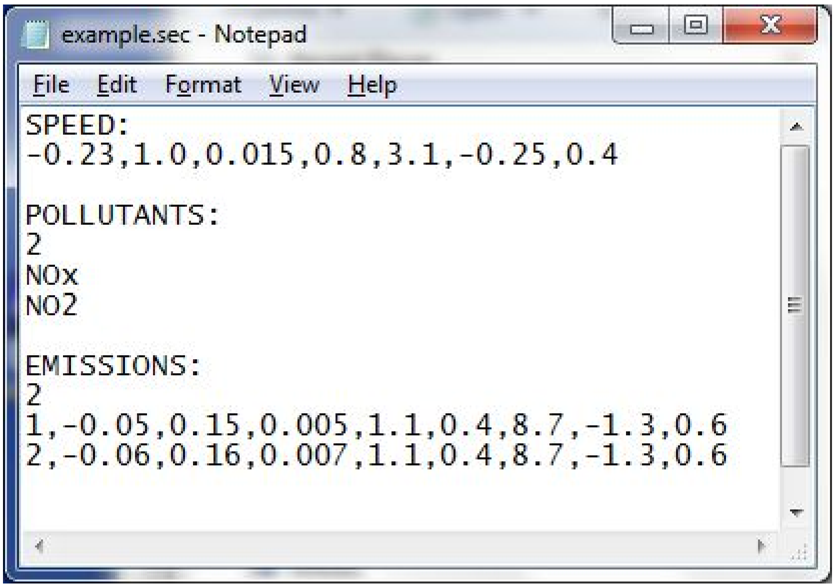


Figure 7.4 – An example of a *.sec* file

The file is split into three sections:

- The first describes the development of speed for all **Air File** categories referring to an **emissions curve**. Denoted by the header 'SPEED:' and followed by the coefficients A_S - G_S.
- The second describes the pollutants affected by the emission development curves. Denoted by the header 'POLLUTANTS:' and followed by the number of pollutants affected and the names of those pollutants.
- The third describes the development of emissions for **Air File** categories referring to an **emissions curve**. Denoted by the header 'EMISSIONS:' and followed by a line for each **emission curve** ID including the **emission curve** ID and coefficients A_E – H_E. The number of emissions curves is limited to 20.

The equation for the development of speed is as follows.

$$V = V_{to}\left(A_S\left(\frac{t}{T_{to}}\right)^2 + B_S\frac{t}{T_{to}} + C_S\right)\left(D_S.\tanh\left(E_S\frac{t}{T_{to}} + F_S\right) + G_S\right)$$

V – speed (m/s)

$\mathbf{V_{to}}$ – take-off speed (m/s)

t – time (s)

$\mathbf{T_{to}}$ – take-off time (s)

$\mathbf{A_S}$, $\mathbf{B_S}$, $\mathbf{C_S}$, $\mathbf{D_S}$, $\mathbf{E_S}$, $\mathbf{F_S}$ and $\mathbf{G_S}$ – speed development coefficients

The equation for the development of emissions is as follows.

$$Qfactor = \left(A_E \left(\frac{t}{T_{to}} \right)^3 + B_E \left(\frac{t}{T_{to}} \right)^2 + C_E \frac{t}{T_{to}} + D_E \right) \left(E_E . \tanh\left(F_E \frac{t}{T_{to}} + G_E \right) + H_E \right)$$

Qfactor – emissions factor

$\mathbf{V_{to}}$ – take-off speed (m/s)

t – time (s)

$\mathbf{T_{to}}$ – take-off time (s)

$\mathbf{A_E}$, $\mathbf{B_E}$, $\mathbf{C_E}$, $\mathbf{D_E}$, $\mathbf{E_E}$, $\mathbf{F_E}$, $\mathbf{G_E}$ – normalised emission development coefficients

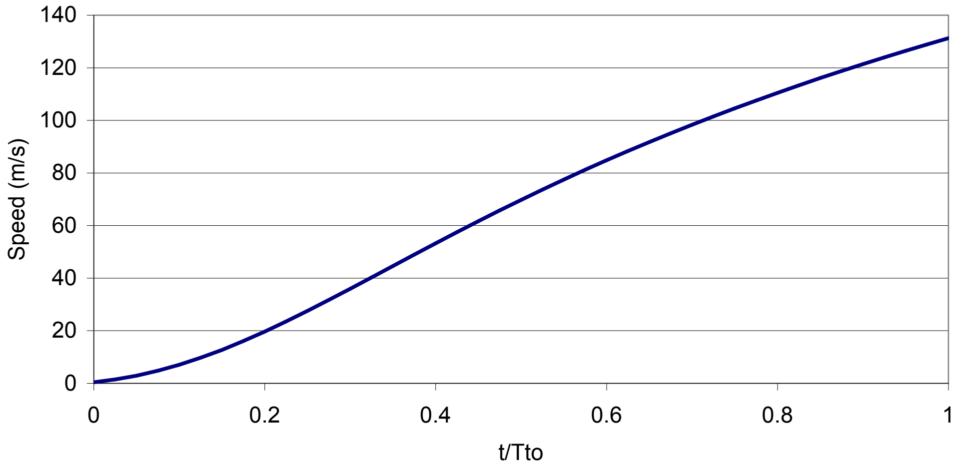
Pollutants in the modelling run but not included in the pollutant list in the *.sec* file are modelled using the speed curve only.

It is important that the emissions curves are ***normalised*** *to ensure they are consistent with the emission rates entered in the* .air *file, i.e. the area under a curve of (t/T_{to}) against Qfactor must be equal to 1.*

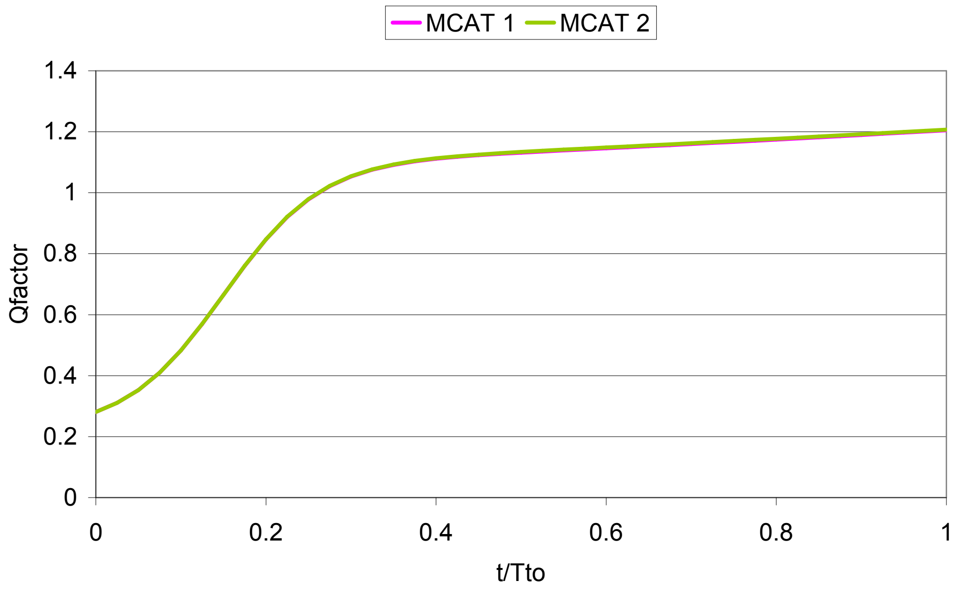
7.2.2 Emission Curve Example File

The emissions curve contains very detailed information regarding the development of aircraft speed and emissions during take-off. Should this level of detail be required you should expect the information required for the *.sec* file to be supplied by the airport operator or aircraft operator.

An example *.sec* file is shown in **Figure 7.4**; development curves are shown for speed and emissions for this example file in **Figure 7.5**.



(a)



(b)

Figure 7.5 – Speed and emission development curves for an example of a *.sec* file
(a) Speed development and (b) Emission development for category 1 and 2 **Air File** sources. The area under the curve of Qfactor is equal to 1.

7.3 Diurnal and monthly time-varying profiles

ADMS-Airport can take account of diurnal and seasonal changes in emissions for each source, and can model sources that are only in operation for a specific range of wind directions. This is done by setting up an extra input file, *.fac*, which contains the emission factors and data linking each source to the appropriate sets of emission factors. The format of the *.fac* file is described in this section.

The full functionality of this option is as follows:

- Hourly factors can be defined for weekdays, Saturdays and Sundays ('3-day diurnal profiles') or for each day of the week ('7-day diurnal profiles'). A different set of factors can be applied to each source.
- Monthly factors can be defined for each month ('monthly profiles'). A different set of factors can be applied to each source.
- Each source can be defined to be in operation only for a specific range of wind directions.
- A single set of profiles can be applied to all road sources not explicitly listed in the *.fac* file, by including a section headed 'default road'.
- A single set of profiles can be applied to all grid cells, by including a section headed 'grid'.

An example time-varying emission factors file is shown in **Figure 7.6**. The file contains three diurnal profiles (two 3-day profiles and one 7-day profile) and one monthly profile, followed by data for two industrial sources, *point1* and *point2*, a road source *road1*, a default road setting *default road* and a grid source *grid*. Note that the data in the file are **factors**, i.e. the emission rates entered on the **Emissions** screen of the interface will be multiplied by these values. The data in the file are as follows.

7.3.1 File Version number

Line 1: `FacVersion3`

Note that ADMS-Airport version 3.4 will also accept .fac files with the FacVersion2 identifier but future versions may not

---

7.3.2 3-day Diurnal profiles

Line 1: Number of 3-day diurnal profiles included in the file
Line 2: Name of the 3-day diurnal profile, up to 20 characters long
Line 3: The 24 hourly factors for weekdays, in order, from hour 1 to hour 24
Line 4: The 24 hourly factors for Saturdays, in order, from hour 1 to hour 24

Line 5: The 24 hourly factors for Sundays, in order, from hour 1 to hour 24
Line 1 must always be included, even if no 3-day diurnal profiles are included in the file. Lines 2-5 are repeated for each 3-day diurnal profile.

After all the 3-day diurnal profile data, there is one blank line before the 7-day diurnal profile data.

7.3.3 7-day Diurnal profiles

Line 1: Number of 7-day diurnal profiles included in the file
Line 2: Name of the 7-day diurnal profile, up to 20 characters long
Line 3: The 24 hourly factors for Mondays, in order, from hour 1 to hour 24
Line 4: The 24 hourly factors for Tuesdays, in order, from hour 1 to hour 24
Line 5: The 24 hourly factors for Wednesdays, in order, from hour 1 to hour 24
Line 6: The 24 hourly factors for Thursdays, in order, from hour 1 to hour 24
Line 7: The 24 hourly factors for Fridays, in order, from hour 1 to hour 24
Line 8: The 24 hourly factors for Saturdays, in order, from hour 1 to hour 24
Line 9: The 24 hourly factors for Sundays, in order, from hour 1 to hour 24

Line 1 must always be included, even if no 7-day diurnal profiles are included in the file. Lines 2-9 are repeated for each 7-day diurnal profile.

After all the 3-day diurnal profile data, there is one blank line before the monthly profile data.

7.3.4 Monthly profiles

Line 1: Number of monthly profiles included in the file
Line 2: Name of the monthly profile, up to 20 characters long
Line 3: The 12 monthly factors for the 12 months, in order, from January to December
Line 1 must always be included, even if no monthly profiles are included. Lines 2-3 are repeated for each monthly profile.

After all the monthly profile data, there is one blank line before the source-specific data.

7.3.5 Source-specific data

Line 1: SrcName, HourlyFlag, MonthlyFlag, WindFlag

SrcName – the source name (this should be ‘grid’ for the grid source)

HourlyFlag – 1 if a diurnal profile (3-day or 7-day) should be applied to this source, 0 otherwise

MonthlyFlag – 1 if monthly factors should be applied to this source, 0 otherwise

WindFlag – 1 if the source is only operational for a specific range of wind directions, 0 if the source is operational for all wind directions

Line 2: Name of the diurnal profile to be applied to this source. This line is only included for sources for which HourlyFlag = 1.

Line 3: Name of the monthly profile to be applied to this source. This line is only included for sources for which MonthlyFlag = 1.

Line 4: PhiStart, PhiEnd

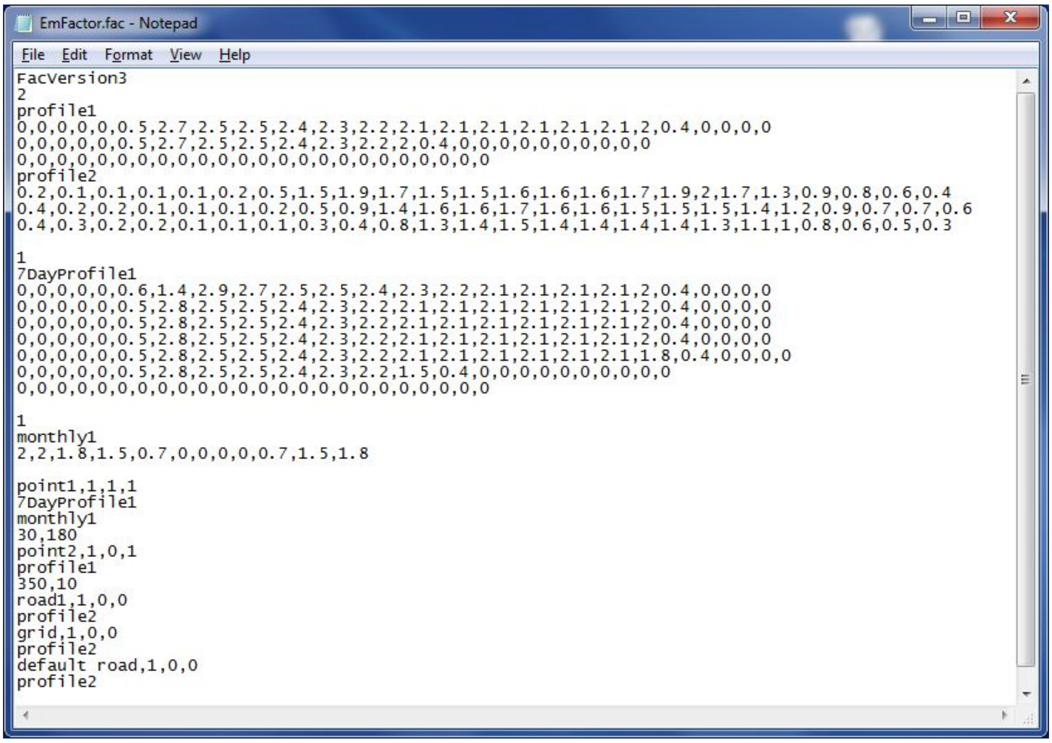
PhiStart – the start of the range of surface wind directions for which the source is operational,

PhiEnd – the end of the range (inclusive). Values are in degrees moving clockwise from North.

This line is only included for sources for which WindFlag = 1.

Line 1 and lines 2-4, if appropriate, are repeated for each source.

In the example shown in **Figure 7.6,** the emissions from *point1* vary with the hour, month and wind direction. The emissions from *point2* vary with the hour, using *profile1*, and the stack is only operational if the wind direction is greater than 350° or less than or equal to 10°. The emissions from *road1* vary with the hour, using *profile2* while the remaining roads will vary with the hour, using *profile2*. The grid source emissions vary with the hour only


EmFactor.fac - Notepad
File Edit Format View Help

```
FacVersion3
2
profile1
0,0,0,0,0,0.5,2.7,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2.1,2.1,2,0.4,0,0,0,0
0,0,0,0,0,0.5,2.7,2.5,2.5,2.4,2.3,2.2,2,0.4,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
profile2
0.2,0.1,0.1,0.1,0.1,0.2,0.5,1.5,1.9,1.7,1.5,1.5,1.6,1.6,1.6,1.7,1.9,2,1.7,1.3,0.9,0.8,0.6,0.4
0.4,0.2,0.2,0.1,0.1,0.1,0.2,0.5,0.9,1.4,1.6,1.6,1.7,1.6,1.6,1.5,1.5,1.5,1.4,1.2,0.9,0.7,0.7,0.6
0.4,0.3,0.2,0.2,0.1,0.1,0.1,0.3,0.4,0.8,1.3,1.4,1.5,1.4,1.4,1.4,1.4,1.3,1.1,1,0.8,0.6,0.5,0.3

1
7DayProfile1
0,0,0,0,0,0.6,1.4,2.9,2.7,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2,0.4,0,0,0,0
0,0,0,0,0,0.5,2.8,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2.1,2.1,2,0.4,0,0,0,0
0,0,0,0,0,0.5,2.8,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2.1,2.1,2,0.4,0,0,0,0
0,0,0,0,0,0.5,2.8,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2.1,2.1,2,0.4,0,0,0,0
0,0,0,0,0,0.5,2.8,2.5,2.5,2.4,2.3,2.2,2.1,2.1,2.1,2.1,2.1,2.1,1.8,0.4,0,0,0,0
0,0,0,0,0,0.5,2.8,2.5,2.5,2.4,2.3,2.2,1.5,0.4,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

1
monthly1
2,2,1.8,1.5,0.7,0,0,0,0,0.7,1.5,1.8

point1,1,1,1
7DayProfile1
monthly1
30,180
point2,1,0,1
profile1
350,10
road1,1,0,0
profile2
grid,1,0,0
profile2
default road,1,0,0
profile2
```

Figure 7.6 – Example time-varying emission factors file (.***fac***)

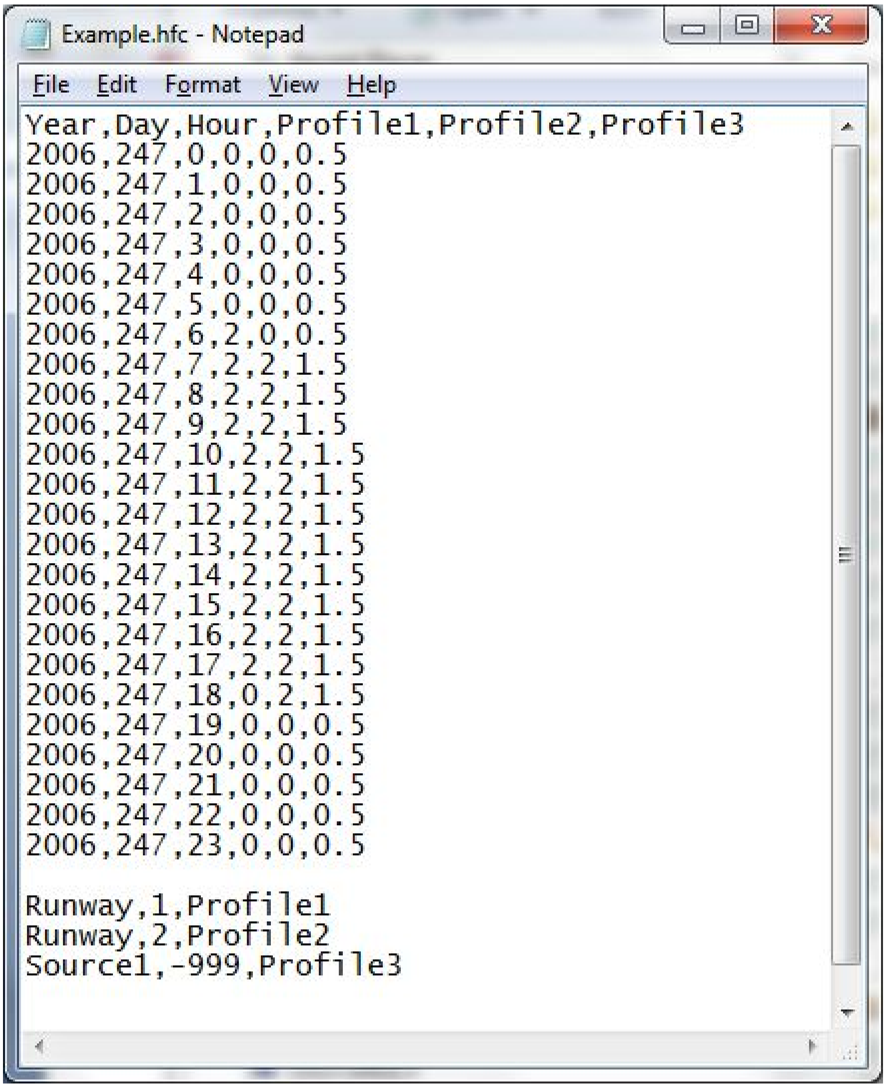
Important points to note

- The name used to identify the grid source must always be ‘grid’.
- None of the text in the file is case-sensitive.
- Source and profile names can contain spaces.
- The file must be in comma-separated format, and source names must not contain commas.
- There should be no blank lines, except for the lines between the 3-day diurnal profile data and the 7-day diurnal profile data, between the 7-day diurnal profile data and the monthly profile data, and between the monthly profile data and the source-specific data.
- Any sources omitted from the *.fac* and *.hfc* file are assumed to be non time-varying, i.e. to have constant emissions.
- Each source can use either a 3-day diurnal profile, with separate hourly factors for weekdays, Saturdays and Sundays, or a 7-day diurnal profile, with separate hourly factors for each day of the week, but not both. Both 3-day and 7-day diurnal profiles can be included in the same *.fac* file, for use by different sources.
- Any wind direction sector limits are applied to the wind direction following the pre-processing of the meteorological data, ie. the wind direction given in the output *.out.met* file rather than the input *.met* file.
- When modelling multiple sources including a grid source, the model applies the time-varying emission factors by disaggregating once at the start of the run, then applying the appropriate time-varying factor to the residual gridded emissions and to each industrial or road source for each met line. However, care must be taken when defining the emissions in the interface. The method works on the basis that the emission rates entered in the **Source** screen for each industrial or road source are the emission rates used to calculate the gridded emissions entered for the grid source. This ensures the disaggregation at the start of the run is correct. Note that the time-varying factors for the grid source will be applied to the residual emissions only.

7.4 Annual hourly time-varying profiles

Annual hourly profiles can be used to vary aircraft, road and industrial source emissions in ADMS-Airport using an *.hfc* file. The **annual hourly profile file** is a comma-separated file with a carriage return between the top and bottom parts of the file. An example **annual hourly profile file** is shown in **Figure 7.7**.

There are two parts to an *.hfc* file. The top part defines one or more profile(s) with associated emission factors. This will usually contain 8761 lines if modelling one year (a header line plus 8760 hours of data). The bottom part lists the sources with the profile to be applied to each source.




```
Year,Day,Hour,Profile1,Profile2,Profile3
2006,247,0,0,0,0.5
2006,247,1,0,0,0.5
2006,247,2,0,0,0.5
2006,247,3,0,0,0.5
2006,247,4,0,0,0.5
2006,247,5,0,0,0.5
2006,247,6,2,0,0.5
2006,247,7,2,2,1.5
2006,247,8,2,2,1.5
2006,247,9,2,2,1.5
2006,247,10,2,2,1.5
2006,247,11,2,2,1.5
2006,247,12,2,2,1.5
2006,247,13,2,2,1.5
2006,247,14,2,2,1.5
2006,247,15,2,2,1.5
2006,247,16,2,2,1.5
2006,247,17,2,2,1.5
2006,247,18,0,2,1.5
2006,247,19,0,0,0.5
2006,247,20,0,0,0.5
2006,247,21,0,0,0.5
2006,247,22,0,0,0.5
2006,247,23,0,0,0.5

Runway,1,Profile1
Runway,2,Profile2
Source1,-999,Profile3
```

Figure 7.7 – An example *.hfc file*

A source cannot be listed in both the .hfc and .fac files.

If a default road profile is used in the .fac file then this default profile is applied to any road sources that are not explicitly listed in either the .fac or .hfc files.

7.4.1 The top of the annual hourly profile file

The top of an *.hfc* file defines a profile and its emission factors. Input data requirements for the top part of an *.hfc* file are shown in **Table 7.8**. The hourly emission factors are normalised and as such the sum of the annual emission factors must be equal to the number of lines in the *.hfc* file. The order must match the order of the Julian day-hour data in the *.met* file used.

Figure 7.8 shows an example of a top of an *.hfc* file opened in Microsoft Excel. The example contains three profiles for a 24-hour period.

Column Heading	Data	Restrictions
Year	Year	4 digits
Day	Julian day	Integer, 1 - 366
Hour	Hour of the day	Integer, 1 - 24
Profile names	Hourly emission factors	≥ 0

Table 7.8 – Column headings for the top of the *.hfc* file

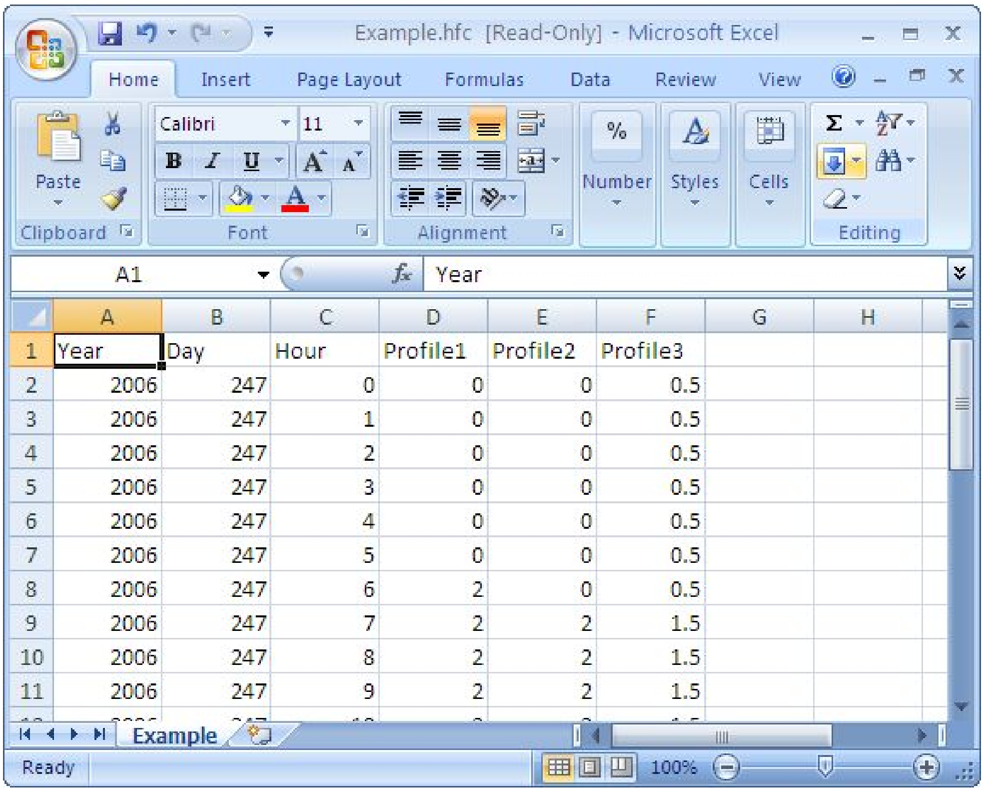


Figure 7.8 – The top of an example *.hfc file* opened in Microsoft Excel

7.4.2 The bottom of the annual hourly profile file

The information in the bottom of the *.hfc* file includes a list of the profiles to be applied to sources during modelling. Where the source is contained in the *.air* file the category number must be used and for all other sources a value of

–999 must be given. There are no column headers input into the bottom of the *.hfc* file.

Figure 7.9 shows an example of a bottom of an *.hfc* file opened in Microsoft Excel.

Column Contents	Data	Restrictions
Source Name	Source name	Must be an **Air File** source, industrial source, road source or grid source
Category	Category number	Where source is an **Air File** source this must match the category in the *.air* file. Otherwise this must be set to –999.
Profile Name	Profile name	Must match a profile declared in the top of the **annual hourly profile file**

Table 7.9 – Column definitions for the bottom of the *.hfc* file

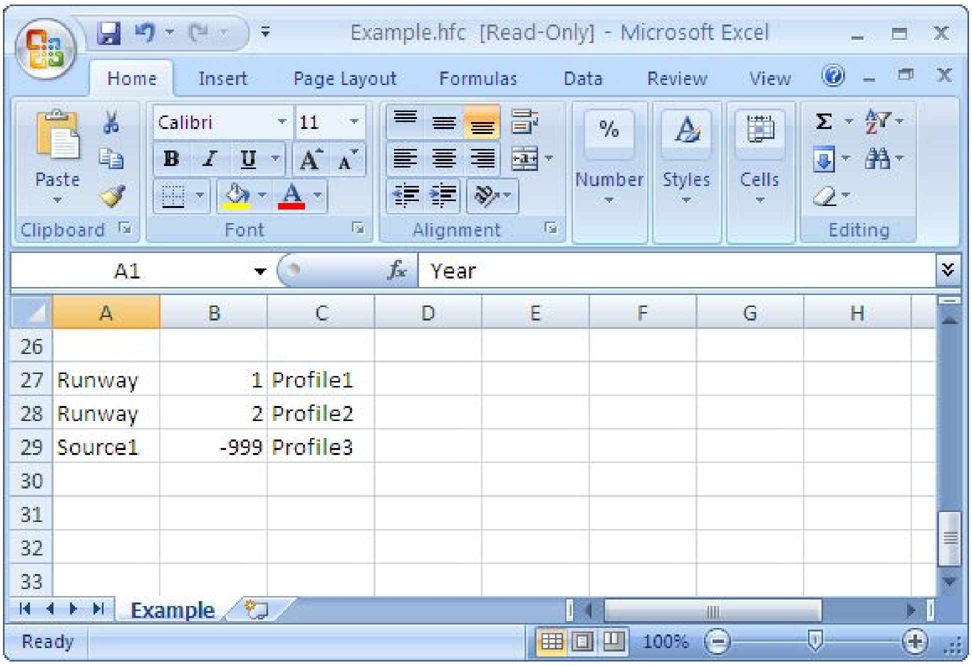


Figure 7.9 – The bottom of an example *.hfc file* opened in Microsoft Excel

SECTION 8 ADMS-Airport Technical Specification

8.1 Air File sources

8.1.1 Introduction

Aircraft can have significant emissions near the ground. It is therefore important to model their dispersion accurately in order to obtain valid predictions of pollutant concentrations in and around airports.

Aircraft engine exhaust emissions usually have high exit velocities relative to ambient wind speeds. Locally, for example during take-off when the aircraft is close to the ground, the source properties of the exhaust jets are important for accurate dispersion modelling. Therefore, ADMS-Airport includes an **Air File** source type that takes into account the effects on the dispersion of exhaust material of exhaust gas buoyancy and momentum as well as aircraft motion.

The more traditional method of modelling emissions from aircraft as volume sources is still valid, and indeed recommended, for other parts of the LTO cycle, such as climb out, where the local source properties are less important.

This section describes the treatment of **Air File** sources as a series of jets in ADMS-Airport.

8.1.2 Treatment of Air File sources in ADMS-Airport

Each **Air File** source is represented in ADMS-Airport as a series of continuous jet source releases, equally spaced along the aircraft's trajectory. Each engine on the aircraft is represented individually, up to a limit of four engines.

Please refer to chapter P11/02 of the ADMS Technical Specification for information about jets and directional releases in ADMS (**CERC** (2013)).

Emission rates are defined in the *.air* file as continuous annual average emission rates. The model adjusts the input emission rate according to the input number of hours of runway use in the inventory year, to ensure that the total annual emission is unchanged; this time-varying adjustment of the annual average emission rate can be done using an *.hfc* file, with further details as given in Section 7.4.

The user is required to enter a number of engine parameters for each aircraft category, which enable ADMS-Airport to model the aircraft jet releases; these are exhaust exit velocity V_e, exhaust temperature T and exhaust diameter D. These can be calculated from typically-available data as described below.

8.1.3 Air File source jet component parameters

Background information

Commercial passenger aircraft tend to use high-bypass ratio turbofan jet engines, such as the one sketched in **Figure 8.1**, due to their superior fuel efficiency. The term 'bypass' refers to the air that passes through the fan at the front of the engine, but 'bypasses' the engine core itself, gaining momentum from the fan only. The 'core' flow is the air that feeds the engine core, which is first compressed to very high pressures in the 'compressor' and then mixed with fuel and raised in temperature in the 'fuel burner'. This hot gas is used to drive the turbine that powers the compressor and fan shaft and then the nozzle converts the high pressure to high velocity, generating thrust. The ratio of bypass flow to core flow is termed the engine's 'bypass ratio'.

In the derivations below, the exhaust flow is assumed to be the mixture of the hot core and cool bypass flows, and this mixture is assumed to be uniform in temperature and velocity.

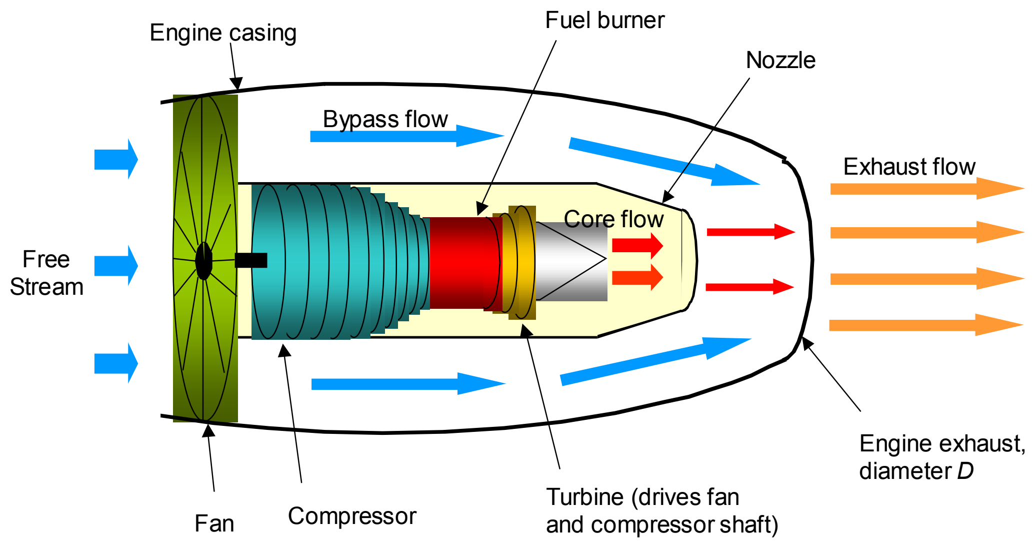


Figure 8.1 – Schematic diagram of the airflow through a high-bypass ratio turbofan jet engine

Derivation of the exit velocity

The aircraft thrust is equal to the rate of change of momentum of air passing through the aircraft engine:

$$Thrust(N) = \dot{m}(V_e - V_0)$$

where $\dot{m}$ is the total mass flow rate, V is the flow velocity and the subscripts 0 and e refer to values at entry and exit from the engine respectively, relative to the moving aircraft; V_0 is the aircraft speed.

Rearranging this gives

$$V_e = \frac{Thrust}{\dot{m}} + V_0 .$$

The exit velocity relative to a stationary observer on the ground is therefore

$$V_e - V_0 = \frac{Thrust}{\dot{m}} .$$

Engine thrust (N) and mass flow rate (kg/s) data during take-off are both available in the spreadsheets accompanying the textbook ‘Civil Jet Aircraft Design’ (**CIVIL 2008**).

Derivation of the source temperature T

The amount of energy per second produced by the combustion of aviation fuel in the engine, Q (J/s), can be derived from the fuel flow rate during take-off, $\dot{f}$ (kg/s) **(ICAO, 2007)** and the known energy of combustion of aviation fuel (43.5 MJ/kg from **Aircraft Fuel 1997**):

$$\dot{Q} = \dot{f} \times 43.5 \times 10^6 \text{ J/s}$$

The thermal efficiency η of an aircraft engine is the ratio of the total work done by the engine to the total energy obtained from fuel combustion. This can be estimated as

$$\eta = \frac{\text{Power output} + \text{Kinetic energy gained by the air}}{\text{Energy from fuel combustion}}$$

Thermal efficiency can also be written

$$\eta = \frac{Thrust \times V_0 + \frac{1}{2}\dot{m}(V_e - V_0)^2}{\dot{Q}}$$

The amount of heat available to raise the temperature of the exhaust is $(1-\eta)\dot{Q}$.

Once we have estimated the thermal efficiency η, it is possible to estimate the temperature of the exhaust gases:

$$T_{exhaust} = T_{ambient} + \frac{(1-\eta)\dot{Q}}{\dot{m}c_p}$$

Where c_p is the specific heat capacity of dry air at constant pressure, which is 1000.4 J/kg/K.

Derivation of the source diameter D

No data are typically available for the engine exhaust diameter *D*, although it is typically approximately equal to the fan diameter for turbofan engines with separate jets, and equal to three quarters of the fan diameter for mixed flow engines[9] (**Figure 8.1**). However, the diameter can be derived from the Ideal Gas Equation:

$$P = \frac{\rho R_*(T + 273.15)}{M},$$

where *P* is the pressure (taken to be 101300 Pa), M is the molar mass of air (0.02896 kg/mol), R_* is the Universal Gas Constant (8.314 J/(Kmol)), *T* is the source temperature and ρ is the density, defined as:

$$\rho = \text{density} = \frac{\dot{m}}{\frac{\pi D^2}{4} \times V_e}.$$

Therefore:

$$D(m) = \sqrt{(T + 273.15) \times \frac{\dot{m}}{V_e} \times \frac{8.314}{0.02896 \times 101300} \times \frac{4}{\pi}}.$$

8.1.4 Effect of the moving aircraft on jet plume dispersion

All discussions in this section refer to the components of the motion which are in the horizontal plane.

For a jet source, such as an aircraft engine, moving through the air with a speed V_A, the dispersion of material is different to the case where the jet source is stationary. In a frame of reference moving with the source, the aircraft speed acts as an extra component of the wind speed.

In the jet source dispersion calculations in ADMS-Airport, we consider two frames of reference: one moving with the source at a speed V_A, and the other stationary. The plume rise part of the dispersion calculations is carried out in

9 Paul Madden, Rolls Royce Group PLC, private communication, 9 July 2004

the moving frame, where the ambient wind speed is modified to include the additional component induced by the movement of the source (resulting in an ‘effective’ wind speed). In the moving frame, the exit velocity is also increased, because the inflow velocity to the engine is increased, and the engine must maintain the same acceleration of the airflow in order to maintain thrust. The rest of the dispersion calculations (calculation of plume spread and concentration) are done in the stationary frame as they are more related to the ambient meteorological conditions.

Effective wind speed U’ and direction φ’

The additional wind speed V_A experienced by the engine in the moving frame affects the effective wind direction as well as the effective wind speed (see Figure 8.2). In terms of the velocity (i.e. speed vectors), if the aircraft moves with speed $V_A = |\boldsymbol{V_A}|$ in a direction $-\boldsymbol{V_A}$, then the jet release direction is $\boldsymbol{V_A}$. Therefore:

- for a zero ambient wind, the effective wind speed in the moving frame of reference is $\boldsymbol{V_A}$, and
- for a non-zero ambient wind, the effective wind speed in the moving frame of reference is $\boldsymbol{V_A} + \boldsymbol{U}$, where $\boldsymbol{U}$ is the ambient wind speed vector.

If the ambient wind direction is φ (measured clockwise from north in the usual way) and the jet release direction is α (measured anticlockwise from east), the resultant ‘effective wind’ speed U' and direction φ' are described as follows:

$$U' = \sqrt{(U_E')^2 + (U_N')^2}$$
$$\phi' = \tfrac{3\pi}{2} - \arctan\left(U_N' / U_E'\right),$$

where U_E' and U_N' are the components of U' in the eastwards and northwards directions respectively:

$$U_E' = U \times \cos\left(\tfrac{3\pi}{2} - \phi\right) + V_A \times \cos\alpha$$
$$U_N' = U \times \sin\left(\tfrac{3\pi}{2} - \phi\right) + V_A \times \sin\alpha,$$

and $U = |\boldsymbol{U}|$.

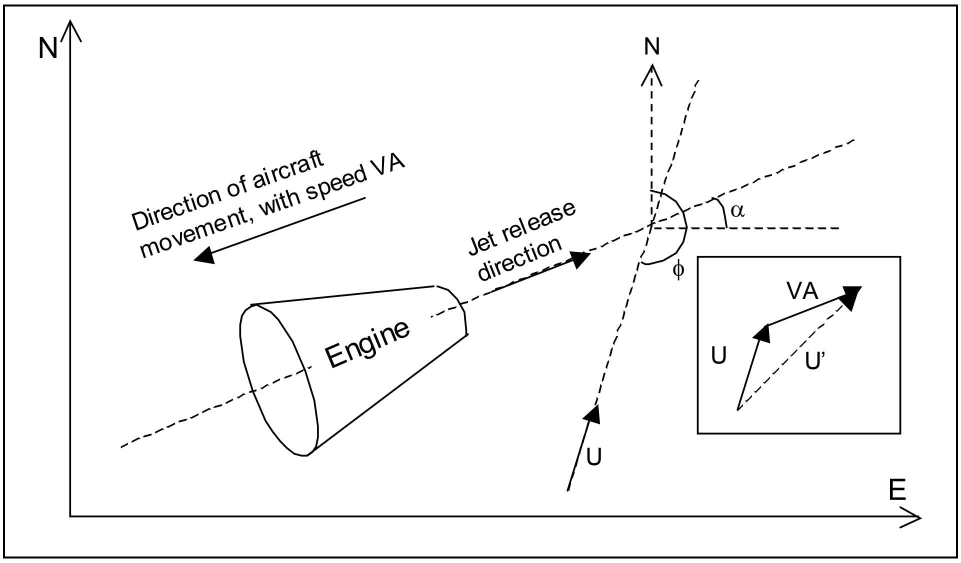


Figure 8.2 – Schematic representation of the effective wind direction in relation to the ambient wind direction and the aircraft travel direction

Transformation of the plume trajectory between moving and stationary frames of reference

The plume trajectory in the stationary frame is represented by the coordinates (X,Y) where X is the distance from the source in the ambient wind direction and Y is the distance from the source in a direction perpendicular to the ambient wind direction.

The plume trajectory in the moving frame is represented by (X',Y') where X' is the distance from the source in the effective wind direction and Y' is the distance from the source in a direction perpendicular to the effective wind direction.

The plume rise calculations are carried out in the moving frame, where the plume trajectory is represented by (X',Y'); the rest of the dispersion calculations are carried out in the stationary frame, where the plume trajectory is represented by (X,Y).

The transformation of the plume trajectory between the two frames of reference has two parts:

- Rotation of the plume trajectory to account for the difference between the ambient wind direction and the effective wind direction, and
- Translation of the plume trajectory to account for the distance travelled by the moving frame.

Rotation

For the rotation part of the transformation between stationary and moving frames of reference, if γ is the angle between the ambient wind direction and the effective wind direction (measured anti-clockwise from the ambient wind direction to the effective wind direction) then:

$$\gamma = \varphi - \varphi',$$

$$X' = X\cos\gamma + Y\sin\gamma \text{ , and}$$

$$Y' = -X\sin\gamma + Y\cos\gamma \text{ .}$$

Translation

Please refer to Figure 8.3 for a schematic of the translation in the simplest case, where the aircraft direction of travel is opposite to the wind direction. In time *dt*, the plume travels from $x{=}x_0$ a distance $Up \times dt$ in the stationary frame of reference, to the point represented by the black block on the figure, where *Up* is the plume speed, i.e:

$$x = x_0 + Up \times dt$$

In the moving frame, the plume speed is *Up'*, so the position *x'* in the moving frame after time *dt* is represented by:

$$x' = x_0 + Up' \times dt$$

Up and *Up'* are related by:

$$Up' = Up + Va$$

Solving the above three equations leads to:

$$x' = x + Va \times dt.$$

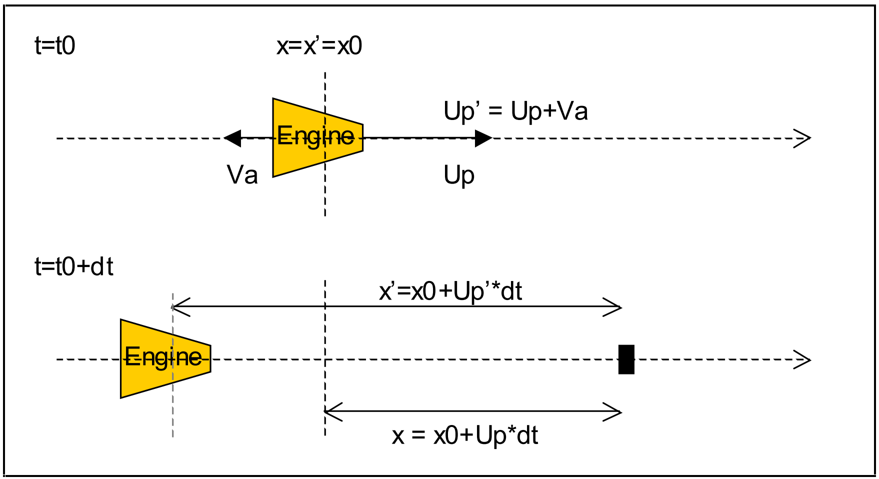


Figure 8.3 – Schematic of the translation between moving and stationary frames of reference for an aircraft engine travelling with speed Va, where the ambient wind and the aircraft speed are in opposite directions

In the more general case, where the ambient wind and the aircraft are not travelling in opposite directions (refer to Figure 8.4): if β is the angle from the aircraft direction of travel to the effective wind direction (measured anticlockwise), then:

$$\beta = \left(\tfrac{3\pi}{2} - \varphi'\right) - \alpha$$
$$X' = X + V_A t \cos\beta$$
$$Y' = Y - V_A t \sin\beta$$

where *(X,Y)* has already been rotated to the effective wind direction and t is the elapsed time since the plume left the source.

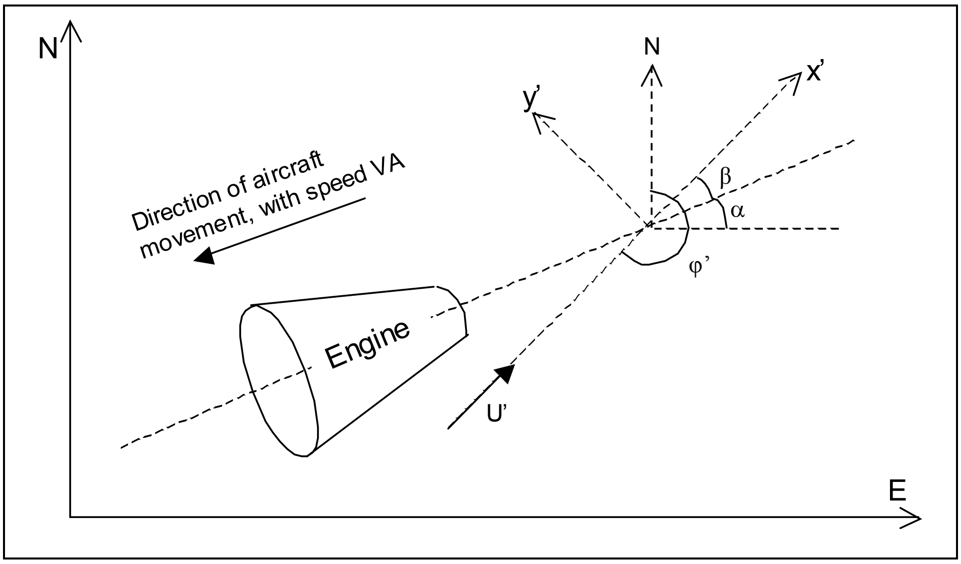


Figure 8.4 – Schematic representation of the relationship between the movement of the aircraft and the rotated frame of reference aligned with the effective wind direction

Transformation of the plume velocity between moving and stationary frames of reference

The plume velocity as calculated by the plume rise calculations is, of course, the plume velocity in the frame of reference moving with the source, and therefore it will be notated here as (U_P', V_P'). The plume velocity is used in various other parts of the dispersion calculations, where it must be the plume velocity in the stationary frame of reference, i.e. (U_P, V_P). The transformation from (U_P', V_P') to (U_P, V_P) is very similar to the inverse of the transformation described above for the plume trajectory (outlined above) i.e. firstly, the translation:

$$U_P'' = U_P' - V_A \cos\beta$$
$$V_P'' = V_P' + V_A \sin\beta \quad ,$$

and, secondly, the rotation:

$$U_P = U_P''\cos\gamma - V_P''\sin\gamma$$
$$V_P = U_P''\sin\gamma + V_P''\cos\gamma \quad .$$

Jet exit velocity in the moving frame of reference

The exit velocity V_e input by the user for a particular aircraft category is considered to be the engine exhaust exit velocity in the stationary frame of reference, in zero wind conditions. This is due to the assumptions made during the derivation of the exit velocity from the thrust value, i.e. zero inflow speed. The actual exit velocity in the stationary frame is therefore the input value plus the component of the wind in the jet release direction. In the moving frame, the exit velocity V_e' is the value in the stationary frame plus the aircraft speed.

$$\beta_0 = (\tfrac{3\pi}{2} - \varphi) - \alpha$$
$$V_e' = V_e + U\cos\beta_0 + V_A \, .$$

8.1.5 Apportionment of emissions between jets

Constant acceleration

As mentioned in the introduction, each entry in the *.air* file is represented in ADMS-Airport as a series of continuous horizontal jet source releases. This section outlines how the emission rate Q (g/s) given in the *.air* file is apportioned between the jets that make up the source.

The number of jets used to model a particular source, NT, is a user-defined parameter, given for each *.air* file entry. In addition, for a particular *.air* file source entry, the user specifies (as given in **Table 7.3**):

(X0,Y0) – the (x,y) coordinates of the aircraft starting position (m)

(X1,Y1) – the (x,y) coordinates of the aircraft finishing position (m)

In the case of constant acceleration (i.e. if a speed curve has not been specified via a *.sec* file – further details given in the section below), the distance travelled by the aircraft, L, is calculated by the model as:

$$L = \sqrt{(X1 - X0)^2 + (Y1 - Y0)^2} \, .$$

The distance L is split into NT sections of equal length. The jet sources are placed longitudinally at the centre of each section, and transversely at locations corresponding to the engines. For example, Figure 8.5 is a diagram showing the flight path from (X0,Y0) to (X1,Y1) for an aircraft with two wing-mounted engines, and NT=9. The direction of travel is from left to right, and red circles show the locations of the jets.

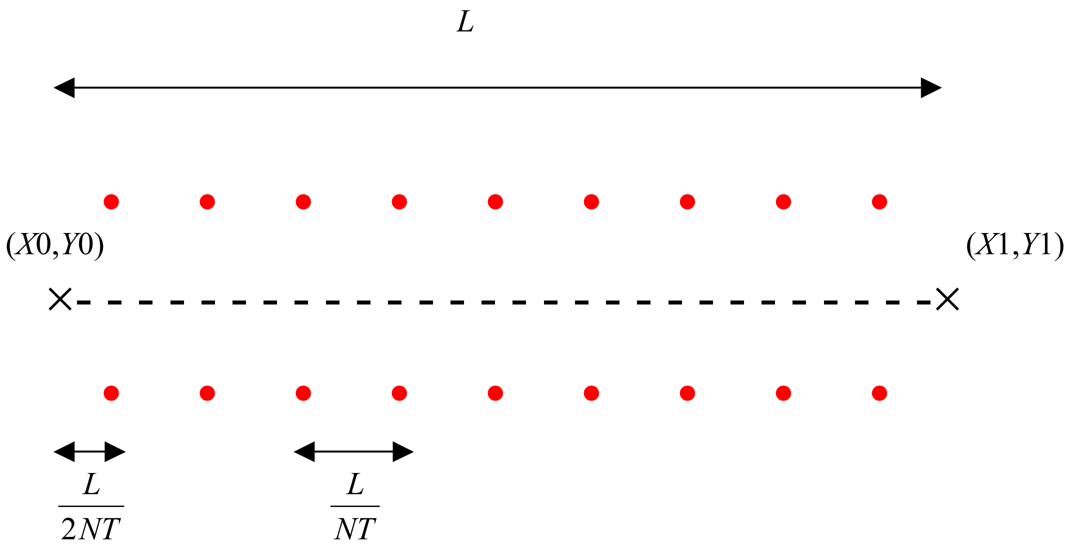


Figure 8.5 – Location of jets relative to *.air* file source entry locations for the constant acceleration case

Figure 8.6 shows example velocity curves for accelerating (full line) and decelerating (dashed line) aircraft. The emission rate, Q (g/s), is apportioned according to the time taken for the source to travel between jet locations. This means that if a plane is accelerating, for example during take-off or climb out, the emission rates for individual jets decrease along the source; conversely when a plane is decelerating, for example during the landing roll, the emission rates for individual jets increase along the source.

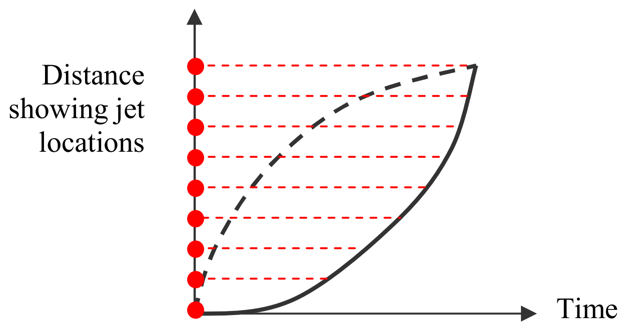


Figure 8.6 – Example velocity curves, with the full line indicating an accelerating trajectory, and the dashed line indicating a decelerating trajectory

8.2 Source oriented grids for Air File sources

8.2.1 Introduction

The concentration gradients across a runway are significant; therefore ADMS-Airport includes a gridding tool called Source-oriented gridding to increase output grid resolution around runways.

The **Source-oriented grids** option also can apply to road and line sources; this section deals only with **Air File** sources. **Source-oriented grids** parameters for **Road**, **Line**, **Aircraft** source types are summarised in Section 5.3 of this User Guide, with further details given in the ADMS-Urban User Guide. ADMS-Airport also contains **Source-oriented grids** for **Point**, **Area**, **Volume** sources, with more details of this also given in the ADMS-Urban User Guide.

If the user has selected gridded output and the **Source-oriented grids** for **Road**, **Line**, **Aircraft** option, and if the run includes one or more *.air* file source entries, then **Source-oriented grids** for **Air File** sources is activated.

8.2.2 Placement of source-oriented grid points

Each entry in the *.air* file has start and end coordinates. In order to define the geometry of an **Air File** source from the list of *.air* file entries with the same name, the model calculates the coordinates of the smallest 'enclosing rectangle' containing all entries. The width of each *.air* file entry is defined as the distance between its outermost engines. For the purposes of defining the enclosing rectangle, each *.air* file entry is extended by 10 times its width behind the start, in order to resolve the concentration distribution from the jets at the beginning of the **Air File** source (recalling that the jets point backwards relative to the aircraft movement).

Start and end coordinates and a width define the enclosing rectangle for each **Air File** source. ADMS-Airport positions additional output points in and around this enclosing rectangle, up to a maximum of 2000 points (as discussed in Section 5.3). Points are added in sets of 8 where each set of 8 points lies on a line perpendicular to, and centred on, the long axis of the enclosing rectangle. The spacing between each set of 8 points is equal to the maximum of the width of the enclosing rectangle and *MinSpacing*, where

$$MinSpacing = \max\left(0.005 \times GridExtent, S_{\min}\right).$$

Here

$$GridExtent = \sqrt{(DX \times DY)} \ ,$$

DX and *DY* are the sizes of the grid (in metres) in the x and y directions respectively and

$$N_{rwy} = total\ number\ of\ AirFile\ sources$$
$$L_{rwy} = total\ AirFile\ source\ length$$
$$S_{\min} = \frac{8 \times L_{rwy}}{2000 - 8 \times N_{rwy}}.$$

This process of imposing a lower limit on the along-source spacing between sets of points ensures that the resolution is no higher than necessary, and that the available points are distributed evenly.

8.3 Non-constant acceleration for take-off entries in the *.air* file

8.3.1 Introduction

An *.air* file source is assumed to have constant acceleration and constant emission of pollutants. For take-off in particular this is not the case. To address this, the user of ADMS-Airport can specify that the take-off roll exhibits non-constant acceleration and distribute emissions of pollutants variably along the aircraft trajectory.

8.3.2 Speed development during take-off

The development of speed during take-off is assumed to be governed by the equation:

$$V = V_{to}\left(A_S\left(\frac{t}{T_{to}}\right)^2 + B_S\frac{t}{T_{to}} + C_S\right)\left(D_S.\tanh\left(E_S\frac{t}{T_{to}} + F_S\right) + G_S\right)$$

V – speed (m/s)

$\mathbf{V_{to}}$ – take-off speed (m/s)

t – time (s)

$\mathbf{T_{to}}$ – take-off time (s)

$\mathbf{A_S}$, $\mathbf{B_S}$, $\mathbf{C_S}$, $\mathbf{D_S}$, $\mathbf{E_S}$, $\mathbf{F_S}$ and $\mathbf{G_S}$ – speed development coefficients

8.3.3 Emission development during take-off

Development of emissions can be defined for each of the **Air File** take-off categories and applied to specific pollutants. The development of emissions during take-off is assumed to be governed by the equation:

$$Qfactor = \left(A_E \left(\frac{t}{T_{to}} \right)^3 + B_E \left(\frac{t}{T_{to}} \right)^2 + C_E \frac{t}{T_{to}} + D_E \right) \left(E_E . \tanh\left(F_E \frac{t}{T_{to}} + G_E \right) + H_E \right)$$

Qfactor – emissions factor

$\mathbf{V_{to}}$ – take-off speed (m/s)

t – time (s)

$\mathbf{T_{to}}$ – take-off time (s)

$\mathbf{A_E}$, $\mathbf{B_E}$, $\mathbf{C_E}$, $\mathbf{D_E}$, $\mathbf{E_E}$, $\mathbf{F_E}$, $\mathbf{G_E}$ – normalised emission development coefficients

The area under the curve Qfactor against (t/T_{to}) must be equal to 1.

8.4 Estimating engine exhaust parameters

8.4.1 Introduction

Engine exhaust parameters required for modelling aircraft sources using the ADMS jet model may not always be available from the manufacturer. For this reason, a method has been developed of estimating engine exhaust temperature and engine exhaust velocity from the engine bypass ratio (BPR), a more widely available metric.

8.4.2 Estimating parameters

In lieu of manufacturer data, aircraft engine exhaust parameters can be estimated from the bypass ratio of the engine. As part of the DfT Air Quality Studies for Heathrow (**DfT** (2007)) manufacturer data were provided for 10 airframe-engine combinations in 4 modes of operation; take-off, initial climb, landing and taxiing. The BPR of the engines was taken from the ICAO Engine Emissions Databank (**ICAO** (2005)) for the engines specified.

The engine BPRs, exhaust velocity and temperature conditions were plotted, see **Figure 8.7**. There is a clear linear relationship between BPR and exhaust conditions. Engine exhaust velocity and temperature can be estimated using the following equations and data given in **Table 8.1**. This method allows

engine exhaust parameters to be estimated for jet engines larger than 26.7 kN thrust contained in the ICAO Engine Emissions Databank.

Engine Exhaust Velocity $= m_v.BPR + c_v$

Engine Exhaust Temperature $= m_T.BPR + c_T$

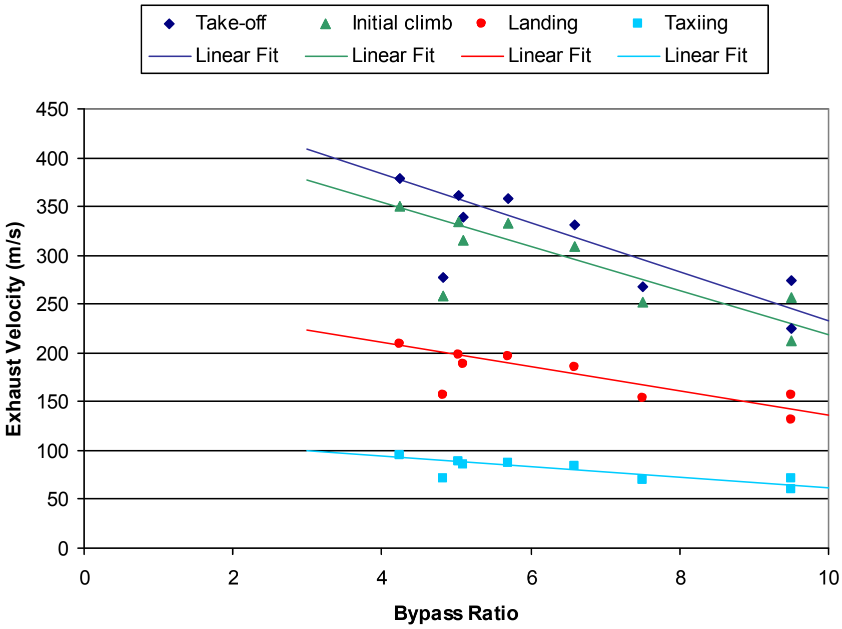
BPR – bypass ratio

m_v, c_v – exhaust temperature coefficients

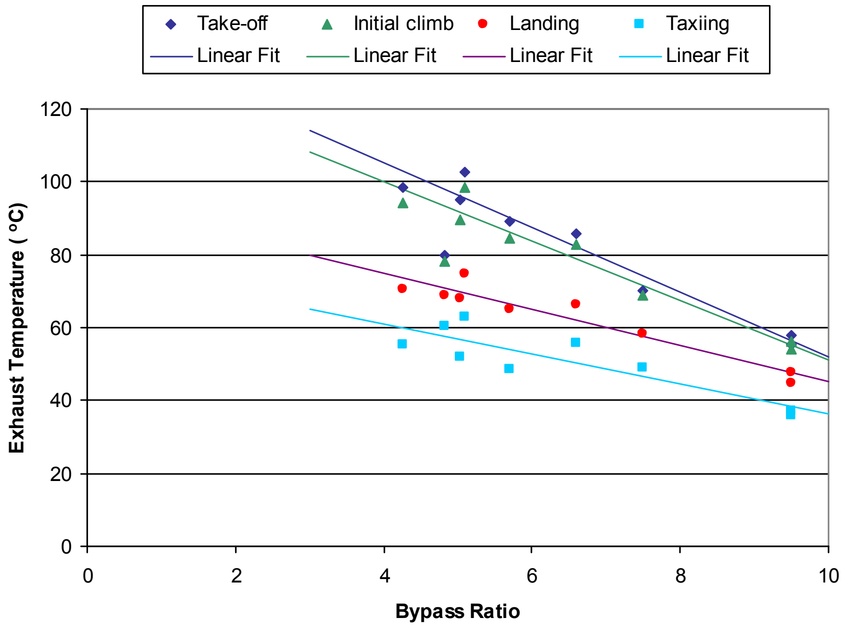
m_T, c_T – exhaust temperature coefficients

Aircraft Mode	Thrust Setting	m_v	c_v	m_T	c_T
Take-off	100%	-25.27	485	-8.86	141
Initial climb	85%	-22.65	446	-8.17	133
Landing	30%	-12.44	260	-4.98	95
Taxiing	7%	-5.52	117	-4.10	77

Table 8.1 – Coefficients for estimating engine exhaust parameters from bypass ratio



(a)



(b)

Figure 8.7 – Relationships between aircraft engine bypass ratio (BPR) and (a) engine exhaust velocity and (b) engine exhaust temperature

SECTION 9 Glossary

Apron	Area where aircraft are parked, unloaded or loaded, refueled or boarded
APU	Auxiliary Power Unit
Bypass ratio	Ratio of cool air by-passed through the duct, to the flow of air passed through the high-pressure system
Fuel farm	Storage of fuel on the airport, i.e. aircraft fuel and GSE fuel
Glide slope	Aircraft angle of approach to airport, usually 3° below the horizontal
GPU	Ground Power Unit
GSE	Ground Support Equipment
LTO cycle	Landing and take-off cycle
MCAT	ADMS-Airport Aircraft Modelling Category
Mode	Aircraft mode of flight, e.g. take-off, initial climb, climb out taxiing etc.
Pier stand	Stand attached to the terminal
Remote stand	Stand remote from the terminal
Runway	A path used by aircraft to take-off and land
Stand	Area where aircraft passengers board and disembark
Taxiway	A path connecting runways to hangars, terminals and other airport facilities
Terminal	Building where passengers transfer between ground transportation and aircraft
TIM	Time In Mode

SECTION 10 References

Aircraft Fuel (1997) Ed. Sybil P. Parker. *McGraw-Hill Encyclopedia of Science and Technology. 8th ed. N.p.: R.R. Donnelly and Sons Company, The Lakeside P.*

CAEP (2008) LAQ Candidate Models Capabilities and Inter-comparison Study. *CAEP-8-MODTF-WP05_LAQ_Sample_problem.*

Carruthers, D. J., Dixon, P., McHugh, C. A., Nixon, S. G. and Oates, W. (2001) Determination of Compliance with UK and Air Quality Objectives From High Resolution Pollutant Concentration Maps Calculated Using ADMS-Urban. *Proc of the 6th Workshop on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, in Intl. J. of Environment and Pollution,* **16**, Nos. 1-6

Carruthers, D. J., Edmunds, H. A., Lester, A. E., McHugh, C. A. and Singles, R. J. (1998) Use and Validation of ADMS-Urban in Contrasting Urban and Industrial Locations. *Intl. J. Environment and Pollution*, **14**, 364-374

CERC (2013) ADMS Technical Specification:
http://www.cerc.co.uk/environmental-software/model-documentation.html#technical

CIVIL (2008) Spreadsheets published online to accompany the textbook 'Civil Jet Aircraft Design':
http://www.elsevierdirect.com/companions/9780340741528/appendices/default.htm

DfT (2007) Air Quality Studies for Heathrow:
http://www.cerc.co.uk/environmental-software/assets/data/doc_validation/ADMS-Airport_Adding%20Capacity_Air%20Quality.pdf

DfT (2006) Project for the Sustainable Development of Heathrow - Report of the Air Quality Technical Panels:
http://www.dft.gov.uk/pgr/aviation/environmentalissues/heathrowsustain/

EPA (1992) Procedure for Emission Inventory Preparation Volume IV: Mobile Sources. *US Environmental Protection Agency*

ICAO (2007) Airport Air Quality Guidance Manual, Preliminary Edition 2007:
http://www.icao.int/icaonet/dcs/9889/9889_en.pdf

ICAO (2005) Engine Emissions Databank (Issue 14).

IPCC (1996) Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volumes 1-3).

McHugh, C. A., Carruthers, D. J. and Edmunds, H. A. (1997) ADMS-Urban: an Air Quality Management System for Traffic, Domestic and Industrial Pollution. *Int. J. Environment and Pollution* **8**, 437-440.

NASA (2007) Beginner's Guide to Propulsion, Glenn Research Center: http://www.grc.nasa.gov/WWW/K-12/airplane/bgp.html

US EPA (1995) AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources Section 7.1. *US Environmental Protection Agency*

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